For Reference

NOT TO BE TAKEN FROM THIS ROOM

Ex libris
universitatis
albertaensis

QUAECUMQUE VERA

THE UNIVERSITY OF ALBERTA

THE DEVELOPMENT OF LOGICO-MATHEMATICAL AND SPATIAL CONCEPTS IN CHILDREN WITH AVERAGE INTELLECTUAL ABILITY WHO ARE LEARNING DISABLED DUE TO DEFICITS IN ARITHMETIC OR READING OR TO EMOTIONAL BEHAVIOR PROBLEMS

BY

© ANNA J. KIRKBRIDE

A THESIS

PRESENTED TO
THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF EDUCATION
IN
SPECIAL EDUCATION

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

SPRING, 1977

Digitized by the Internet Archive
in 2023 with funding from
University of Alberta Library

https://archive.org/details/Kirkbride1977

ABSTRACT

This study investigated the performance by children characterized by different types and combinations of learning disabilities on a Piagetian test battery including five logico-mathematical and three spatial tasks. One hundred and seventeen children were involved in the investigation. Twenty of the children served as normal controls and ninety-seven of the children were learning disabled. The learning disabled children were diagnosed as belonging to five different dysfunction groups: (1) reading disability, (2) arithmetic disability, (3) behavior disability, (4) reading and arithmetic disability and (5) reading, arithmetic and behavior disability. A control group and five dysfunction groups were identified at two age levels, one younger than nine years six months and one older than nine years six months.

The major findings of the investigation were: (1) the children called learning disabled with few exceptions followed the sequence of stages described by Piaget for logico-mathematical and spatial development in normal children; (2) at the younger age level, significant differences existed between the performance of the control group and several dysfunction groups on the Seriation task, a test for mathematical concepts, and two of the spatial development tests, Topographical Positions and the Coordination of Perspectives; (3) at the older age level, significant differences existed between the performance of the control group and several dysfunction groups on the Seriation task, a test for mathematical concepts, the Duality Principle, a test of logical thinking, and two tests of spatial development, the Concepts of Left and Right and

the Coordination of Perspectives; (4) a number of the older children called learning disabled were operational on the Piagetian tasks but continued to experience academic difficulties; (5) arithmetic appeared to be the most serious type of disability in that more areas of deficit seemed to be related to it. The areas of deficit were Seriation, Multiplication of Classes, Concepts of Left and Right and Coordination of Perspectives.

ACKNOWLEDGEMENTS

The assistance of many people made this study possible.

I wish to thank Dr. Lillian Whyte, my advisor, for her support, encouragement, guidance and patience. The scholarly example that Dr. Whyte has set for me is especially appreciated.

The assistance of Dr. R. Mulcahy and Dr. L.D. Nelson, committee members, is acknowledged. Their suggestions and constructive criticism have been most helpful.

Gratitude is extended to Miss Eve Turner, Director of Special Education, Edmonton Public School Board for her interest in and cooperation with the project.

I thank Dr. T. Blowers and Mrs. A. Mulgrew at the Edmonton Public School Board and Mr. H. Unrau at the Glenrose School Hospital for their help in identifying and locating the subjects for the study.

The friendly and willing cooperation of the principals and teachers in the schools I visited is very much appreciated. I especially thank all the children who cheerfully participated in the study.

I am very grateful to Monica Jewell for the preparation of the original and final manuscripts of this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The identification and education of learning disabled children is a controversial issue. Many definitions have been formulated to describe the learning disabled child and numerous and varied curricula have been devised to meet his needs. No one definition of learning disabled children seems to be acceptable to all educators and researchers , however, the majority of current definitions seem to be included within two broad categories. One category contains definitions which describe the learning disability but do not assign etiology to specific causative factors. The other category contains those definitions which relate the learning disability to functional disorders of the central nervous system.

The Kirk (1968) definition is typical of those within the former category.

> A learning disability refers to a specific retardation or disorder in one or more of the processes of speech, language, perception, behavior, reading, spelling, writing or arithmetic.
>
> (p. 398)

The Clements (1968) definition exemplifies those which relate the learning disabilities to central nervous system dysfunction.

> The term "minimal brain dysfunction syndrome" refers to children of near average, average, or above average intelligence with certain learning or behavioral disabilities ranging from mild to severe, which are associated with deviations of function of the central nervous system. These deviations manifest themselves by various combinations of impairments in perception, conceptualization, language, memory, and control of attention, impulse, or motor function.
>
> (pp. 9-10)

Elizabeth Koppitz (1971) has also formulated, on the basis of her research, a very comprehensive definition of the learning disabled child. She attributes the problem to a number of factors, cerebral and neurological impairment being included among them. Koppitz described the learning disabled child as being unable to benefit from the regular school programme despite normal intellectual potential, being more than one year below his mental age in school achievement, and exhibiting no gross motor impairment. Factors cited by Koppitz to account for the learning disability included immaturity or developmental lag, neurological impairment, severe early deprivation, genetically determined cerebral dysfunction, emotional disturbance and minimal brain dysfunction.

It would appear that all these definitions either explicitly or implicitly postulate that the learning disabled child is retarded in one or more developmental functions thought to be related to learning school curricula.

The foremost developmental psychologist of this century, Jean Piaget, formulated a very comprehensive theory of development. It is possible that the developmental lag of the learning disabled child and the difficult question of why this child cannot function at an academic level commensurate with his measured or assumed intellectual potential can be considered in the light of Piaget's (1950) theory of intellectual development. Piaget proposed that the young child progresses through a series of developmental periods each of which is characterized by specific stages. The child's ability to

deal with various types of tasks is hypothesized as dependent upon the stage of intellectual development that he has attained.

Many studies have related the ability to achieve in academic areas and the emotional stability of children to their performance on various Piagetian tasks. The tasks include measures of stage of development of logico-mathematical and spatial concepts, areas of deficit often cited in learning disabled children.

Much of the information currently available concerning learning disabled children is undifferentiated with respect to specific areas of curriculum disability. It would perhaps prove informative to initially identify groups of children with disabilities in specific school subjects and compare their performance on a battery of Piagetian tasks. It could then be determined whether disability in particular subjects is related to specific dysfunction in development of logico-mathematical and spatial concepts. Should such differences exist constructive suggestions regarding curricula for learning disabled children might be offered. Before reviewing some of the investigations that give viable support for this proposal it is necessary to summarize a few of Piaget's contentions regarding the development of logico-mathematical and spatial concepts in the young child. Related research pertinent to his various hypotheses will be mentioned briefly.

CHAPTER I

PIAGETIAN CONCEPTS HYPOTHESIZED TO UNDERLY ACADEMIC ACHIEVEMENT

Logic And The Concept Of Number

Piaget (1952) eloquently explained how the concept of number evolves in the young child. In his book, The Child's Conception of Number, he described cardinal and ordinal correspondence and the manner in which the cardinal and ordinal aspects of number are differentiated and coordinated. The gradual acquisition of the basic additive and multiplicative properties of number by the child was discussed in great detail.

Piaget and Inhelder (1964) elaborated upon the logico-mathematical concepts that contribute to number.

According to Piaget (1952)

> .... the construction of number goes hand in hand with the development of logic, and ... a pre-numerical period corresponds to the pre-logical level ... number is organized stage after stage in close connection with the gradual elaboration of systems of inclusions (hierarchy of logical classes) and systems of asymmetrical relations (qualitative seriations), the sequence of numbers thus resulting from an operational synthesis of classification and seriation ... logical and arithmetical operations therefore constitute a single system ... the second resulting from generalization and fusion of the first, under the complementary headings of inclusion of classes and seriation of relations ... the fusion of inclusion and seriation of the elements into a single operational totality takes place, and this totality constitutes the sequence of whole numbers, which are indissociably cardinal and ordinal.
>
> (p. viii)

Piaget suggested that the development of the concept of number is characterized by three distinct stages. During the first stage of "global comparisons" the child of approximately six years of age is interested in numbers and probably has learned to count. The child's concept of number, however, is extremely vague and judgments about number are tied to perception. Numerical judgment about a given configuration will probably change if it undergoes a perceptual change. There is no conservation of number, that is, no realization that number remains invariant despite the rearrangement of a set of objects. At about the age of seven the child enters the "intuitive stage." Slowly he begins to realize that perceptual transformation does not change the attributes of quantity and number with respect to a given set of objects, however, understanding is not clear and cognition is associated only with judgments about objects confined to his perceptual field. The stage of "concrete operations" is usually reached when the child is approximately eight years of age. Judgment is stable and reversibility of thought is manifest. The child remembers the configuration as it existed before the perceptual change. He knows that perceptual transformation does not change quantity and number and that the altered configuration can be returned to the original state. Performance is still restricted to concrete or perceived objects. Reasoning in the abstract is not achieved until a final stage of formal operations.

Piaget (1952) also studied classification and seriation skills of young children. The two classification abilities which seem to be of importance here are (1) additive composition of classes, that is, the recognition of a sub-class as an integral part of a larger or whole class and (2) multiplicative classification which involves the formation of a new class from two independent classes which overlap with respect to their membership. Regarding seriation, Piaget studied the ability of the child (1) to form a simple qualitative series, (2) to recognize the qualitative correspondence or similarity between two seriations and (3) to recognize the ordinal or numerical correspondence between two seriations. In the experiments that deal with classification and seriation, Piaget demonstrated successive stages of "global comparisons", "intuitive" judgment and "operational" judgment for each of these activities. The stages are very similar to those previously described for number. Piaget stressed that number is not reduced to classes and relations. They are mutually related. Classes are "non-seriated numbers" and numbers are "seriated classes."

> ... this in no way implies that class and asymmetrical relation come before number. On the contrary, number can be regarded as being necessary for the completion of truly logical structures.... Instead of deriving number from class, or the converse, or considering the two as radically independent, we can regard them as complementary, and as developing side by side, although directed towards different ends.
>
> (Piaget, 1972, p. 161)

Piaget hypothesized, therefore, that the abilities to classify and seriate and the acquisition of the concept of number are characterized by the appearance of sequential developmental stages. Furthermore, according to Piaget the truly operational child has integrated the abilities involved in conserving, ordering and classifying at approximately eight years of age. These contentions have sparked a number of replication experiments and related investigations which have tended to support, refute and partially support his findings. Several of these studies will be summarized here.

Dodwell (1960, 1961) demonstrated in a population of 250 children aged five to eight years (IQ 85-116+) the three stages of cognitive development postulated by Piaget with respect to the understanding of number. There was, however, considerable variation in the type of response given at any age level and often the type of response given by an individual child varied from one test to another. Age trends were noted, the older children tending to give more "operational" judgments. The age trends differed for different test situations and IQ, as measured by a group test, was considered a factor in the attainment of number concepts.

A study by Estes, (1956) refuted the existence of developmental stages in the growth of number concept. The test procedures used by Estes, however, have been questioned by other investigators (Modgil, 1974).

Elkind (1961a, 1961b, 1961c) replicated Piaget's experiments related to the development of quantitative thinking, the conservation of mass, weight and volume and class inclusions. His results supported Piaget's findings.

Dodwell (1962) found that understanding of the nature of hierarchical classification, to the extent that this is shown by the ability to answer correctly questions which involve the simultaneous consideration of the whole class and its (two) component subclasses, appeared to develop quite independently of the concept of cardinal number as measured by provoked and unprovoked correspondence tests.

Almy et al. (1966) reported on the conservation abilities of 330 young middle and lower class children in kindergarten, grade one and grade two. The pattern of development tended to support Piaget's contentions. In the middle class school, children able to conserve on all tasks ranged from nine percent in kindergarten to 48 percent in grade two, however, in the lower class school, only one child conserved on all the tasks in kindergarten and only 23 percent of these children conserved by grade two. The kindergarten children were followed in a longitudinal study into grade two. The sequence of acquisition of conservation abilities was again demonstrated, however, there was great individual variation in progress towards conservation.

Logical thinking in second grade children was studied by Almy et al. (1970). Piagetian conservation, classification and seriation tasks were administered to more than 600 children. Almy

stated, that according to Piaget, the child would be expected to conserve quantity prior to weight, arrange a series prior to solving ordination problems and accomplish both of these before reordering a scrambled series. The solution of a transitivity problem would follow seriation, ordination and possibly reordering. Advanced classification would be represented by solution of inclusion problems. The developmental pattern presented by the second grade children was uneven and Almy concluded that it did not support Piaget's idea of the integration of classifying, ordering and conserving skills in children of this age.

Lovell (1972) commenting on his experiences and research in this area said:

> ...in the case of able pupils, once it is available in one type of task, the logical instrument soon becomes available in related tasks, whereas, in the case of less able pupils, horizontal differentials persist much longer. Thus, as logical thought emerges, the child's level of performance is uneven at first, and the unevenness disappears faster in the abler pupil.
>
> (p. 167)

In conclusion, the statements made by Piaget concerning developmental stages with respect to classification, seriation and the growth of the concept of number seem to be supported by the literature. The issue of the relationship between classification, seriation and number is more controversial and is yet to be resolved.

During his discussion of the concept of number Piaget noted that the ability of the young child to count is often overemphasized. He suggested that .... "there is no connection between the acquired ability to count and the actual operations of which the child is capable" (Piaget, 1952, p. 61).

A number of investigators (Dodwell, 1960, 1961; Hood, 1962; LeBlanc, 1968; Steffe, 1966 and Wheatley, 1968) demonstrated that counting is no guarantee of the concept of number. The work of Van Engen and Steffe (1966) is typical of this research. They found that all but one of 100 first grade children could respond correctly to 2 + 3 = 5 on a paper and pencil test and all but six knew that 4 + 5 = 9, however, only 54 pupils correctly stated no preference for separate or combined piles when five candies were used and only 45 when nine candies were used. Many children did not conserve number. Recently Sohns (1974) demonstrated that non-conservers in grades one, two and three could be taught to compute subtraction algorithms involving the facts one through eighteen so that they appeared to have a rational knowledge of subtraction. These studies that relate the apparent ability to perform certain arithmetic operations to the apparent lack of the concept of number support Piaget's hypothesis.

Spatial Development

> .... if the development of various aspects of child thought can tell us anything about the mechanism of intelligence and the nature of human thought in general, then the problem of space must surely rank as of the highest importance.
>
> (Piaget and Inhelder, 1956, p. vii)

Laurendeau and Pinard (1970) have provided an excellent summary of Piaget's views with respect to the development of the child's concept of space. The following brief account of some of the major tenets of the theory has been extracted from this source.

Perceptual space and cognitive space.

Piaget initially makes a distinction between perceptual and cognitive space. This distinction is related to that which he makes between perception and intelligence. Figurative and operational aspects characterize knowledge, according to Piaget. For a child to know an object he must construct or reconstruct it. The operational aspect of knowledge involves the actions or operations employed by the child when he submits an object to the transformations necessary for its reconstruction. The figurative aspect of knowledge is "related to the direct or pictorial perception of the successive states .... between which the transformational activities must intervene" (Laurendeau and Pinard, 1970, p. 9). The child must be able to visualize the sequential states that an object assumes as he reconstructs it. Reconstruction of an object is not an "all at once" process but rather a gradual

process. Intelligence, therefore, does not grow out of perception. Piaget suggested that perception serves as "raw material" for intellectual activity. Intellectual activity reciprocates by exerting an "enriching influence" on perception which thus becomes "more flexible in its function". Intelligence and perception develop in a complementary fashion from sensorimotor activity.

Sensorimotor space and representational space.

Sensorimotor space develops in the child during the first two years of life. This space is "practical, experienced, perfectly organized and balanced at the level of action" (Laurendeau and Pinard, 1970, p. 11). It is primarily dependent on the operative aspect of knowledge and goes far beyond the confines of perception.

When "symbolic function" becomes available to the child of approximately two years of age, he is capable of acting both upon objects physically present in his perceptual field and those which are symbolized or mentally represented. This event marks the beginning of the development of representational space and will involve a process of internalization that will not be completed until the child has reached the age of twelve. The "intuitive or pre-operational" stage of representational space is characterized by "static and irreversible" representations and occurs during the age range of two to seven years. It is followed by the "operational" stage in which the internalized actions become "mobile and reversible." At first the operations are concrete and depend upon

the manipulation of real or represented objects. This stage develops during the years seven to twelve. When the stage of "formal operations" is reached, thought becomes abstract and removed from real actions.

Flavell (1963) suggested that Piaget

> .... is almost obsessional in (his) reiteration that these spatial representations are built up through the organization of actions performed on objects in space, at first motor and later, internalized actions which eventuate in operational systems. Our adult representation of space is thus said to result from active manipulations of the spatial environment rather than from any immediate "reading off" of this environment by the perceptual apparatus .... we eventually come to "see" the objects as together or separated in space, much less as a function of past visual enregistrations of their proximity or separation than from past actions of placing objects together and separating them.
>
> (p. 328)

Piaget described two stages in the development of representational space. The first stage is characterized by the acquisition of concepts of topological space. The concepts of projective and Euclidean space are acquired during the second stage.

To investigate the properties of topological space Piaget and Inhelder (1956) conducted experiments involving haptic perception (perception by touch without vision), drawings, linear and circular order, the study of knots and the idea of points and continuity. Projective space was studied with experiments in the construction of the projective straight line, the projection of shadows, the coordination of perspectives, geometric sections and the rotation and development of surfaces. Among the methods used to investigate the

transition from projective to Euclidean space were (1) the use of transformations wherein parallels were conserved, (2) situations which revealed the similarities and proportions of figures such as rectangles and triangles, and (3) experiments which dealt with the understanding of systems of reference and horizontal and vertical coordinates.

Initially, children construct their space using the primitive relationships of proximity, separation, order, enclosure and continuity. These topological relationships are independent of changes in the size of a figure and distance since angles and straight lines are not conserved during changes in shape. Using topological relations the position of each figure is considered in isolation. Piaget postulated that the topological space of the child is "a mosaic of fragmentary and distinct spaces" (Laurendeau and Pinard, 1970, p. 167). These separate spaces must be coordinated into a total space before the child understands spatial structures. The formation of two distinct and complementary systems accomplish the required coordination. Piaget suggests that these systems are:

> (a) A system of axial coordinates, the source of Euclidean space, in which external objects may be located in relation to one another and placed within a single comprehensive structure which includes the objects as well as the positions themselves.....
> (b) A system of perspectives, the source of projective space, which also assures the coordination of the same objects but this time considers them in relation to the different actual or potential points of view which can be produced by considering them in relation to one another.

> While distinct, these two systems are rigorously connected and formed concomitantly in the course of development. Coordination of perspectives, in fact, implies the organization of a stable system of reference around which the projective left-right, before-behind, and above-below dimensions can be established in relation to the successive positions of a single observer (or to the simultaneous positions of several different observers). Conversely, the construction of spatial coordinates requires a differentiation of these various perspectives, without which it is impossible to conceive a reference system which is independent of the temporary point of view or to structure the three basic dimensions of Euclidean space.
> (Laurendeau and Pinard, 1970, pp. 167-168)

Concannon (1970) reviewed the research on haptic perception and cited major studies in the area to be those of Fisher (1965), Lovell (1959), Page (1959) and Peel (1959).

Lovell (1959) studied haptic perception in 150 children aged three to six years. The children generally discriminated topological properties earlier than Euclidean ones and they experienced considerable difficulty in representing the appearance of objects as seen from perspectives other than their own. Lovell's subjects tended to perform on higher levels than Piaget's subjects of the same age.

Page (1959) confirmed the primacy of topological relations and the Peel (1959) data for the stage-by-stage progression in spatial representation correlated highly with that outlined by Piaget.

Fisher (1965) hypothesized that children recognize topological shapes more readily than Euclidean (linear) shapes because they have more words available with which to identify topological configurations. Prior to a test of tactile recognition, an experimental group of young children learned names for topological

and Euclidean test shapes. A control group observed the shapes prior to testing but did not learn their names. Results showed that the experimental group recognized the Euclidean shapes more easily than the topological shapes whereas the converse was true for the control group. Fisher's results would seem to partially support his hypothesis and to partially support Piaget's views.

Recently, Laurendeau and Pinard (1970) replicated Piaget's experiment involving the stereognostic recognition of objects and shapes with 337 children. Their findings supported Piaget's conclusions.

> Projective space ... begins psychologically at the point when the object or pattern is no longer viewed in isolation, but begins to be considered in relation to 'a point of view'. This is either the viewpoint of the subject, in which case a perspective relationship is involved, or else that of other objects on which the first is projected.
>
> (Piaget and Inhelder, 1956, pp. 154-155).

At this time it is necessary to mention "egocentrism" a central concept in Piaget's theory of intellectual development. Egocentrism refers to a cognitive state in which the individual sees the world from only one point of view or perspective - his own. The individual is literally a prisoner of his own viewpoint, he is not even aware that other points of view exist.

> .... Through an apparently paradoxical mechanism whose parallel we have described apropos of the egocentrism of thought of the older child, it is precisely when the subject is most self-centered that he knows himself the least, and it is to the extent that he discovers himself in the universe and constructs it by virtue of that fact.

> In other words, egocentrism signifies the absence of both self-perception and objectivity, whereas acquiring possession of the object as such is on a par with the acquisition of self perception.
>
> (Piaget, 1954, p. xii)

Piaget (1928) studied the development of the concept of left and right in the child. This is one of the most elementary concepts of projective space and is linked with egocentrism. The child passes through three stages with respect to the distinction of left and right. The stages are characterized by decreasing egocentrism and by the socialization of thought. During the first stage, the child of five to eight years, can only designate the parts of his own body in terms of left and right. He is restricted to his own point of view. During the second stage, the child of eight to eleven years, can correctly designate left and right on the body of a person facing opposite. This period is marked by the decline of primitive egocentrism and the child can consider the other person's point of view. At the third stage, around eleven to twelve years, the child can consider the concepts of left and right from the point of view of things themselves. The child can reason from every point of view at once. Laurendeau and Pinard (1970) replicated Piaget's original experiments which traced the developmental course of the concepts of right and left. Their findings support those of Piaget.

The coordination of perspectives is a more advanced concept of projective space. Piaget investigated this aspect of development of projective space with his classic "three mountains" experiment.

The young child was presented with a mock landscape of three "mountains" of different sizes and asked to select from a number of colored pictures the view seen by a "little man" as he moves around the landscape. The child is required to manipulate two dimensions in this experiment, left-right and before-behind. The process of logical multiplication is involved. The child must coordinate the relative positions of several objects among themselves and of each of these objects in relation to a mobile observer. Again Piaget proposed a series of stages through which the child passed before achieving solution of the problem. During Stage I (age four to seven years) the child's responses are always egocentric. No matter where the observer is placed the child always selects the picture that represents his own view of the landscape. During Stage II (age seven to eight years) partial decentration occurs. The child seems to be aware of perspectives other than his own, however, he often cannot justify the non-egocentric responses he makes. Stage III (age nine to ten years) is one of operational coordination. The child no longer makes egocentric errors. He is aware of the perspectives of others and can justify the choices he makes.

Piaget's views concerning the coordination of perspectives have attracted a great deal of attention and many articles related to them have appeared in the literature. There is wide disagreement with respect to the age at which a child is capable of entertaining perspectives other than his own. Ages ranging from two to sixteen years have been reported (Flavell et al. 1968).

Eiser (1974) reviewed the research related to the coordination of perspectives in a systematic and informative manner. She noted that the original Piaget and Inhelder (1956) experiment presented the child with a model and asked him to make a prediction or an inference about what the doll saw. The child was allowed to walk around the model only to check the view of the doll. Dodwell (1963) and Laurendeau and Pinard (1970) used this procedure. Other investigators (Houssidas, 1965; Brodzinsky et al., 1972; Fishbien et al. 1972) allowed the child to look at the objects from a number of different positions before he was asked to predict the view of the doll. Eiser (1974) suggested that the child was being asked to recognize perspectives in these situations, not predict them. Another difficulty that arises is the position of the doll when the child is asked to predict or recognize its viewpoint. Some investigators (Schantz and Watson, 1970) limited judgment to the position 180^{o} to the subject's own. Piaget (1928) noted the early emergence of the front-back compared to the left-right concept and this finding was supported by Harris and Stommen (1972). Others have used the positions which include both the back-front, left-right transformations (45^{o} and 60^{o} intervals) as did Piaget and Inhelder (1956). Among these investigators are Aebli (1967), Garner and Plant (1972) and Laurendeau and Pinard (1970). Summarizing her findings Eiser (1974) concluded that the studies that used recognition procedures reported lower ages of mastery than those using inference procedures. The lowest age of mastery was two years and was reported when the child was asked to recognize the viewpoint of another at 180^{o} to himself (Flavell et al., 1968). This was followed

by 90^{o} and the higher age levels reported involved intervening positions.

The child's representation of space culminates in the construction of systems of reference or coordinates (Piaget and Inhelder 1956). Originally these coordinates are simply:

> ... a vast network embracing all objects and merely consist of relations of order applied simultaneously to all three dimensions. Within this network each object is linked simultaneously with the rest in three directions, left-right, above-below and before-behind along straight lines parallel to each other along one dimension and intersecting those belonging to the other two dimensions at right angles.
> (Piaget and Inhelder, 1956, p. 375)

When horizontality and verticality no longer depend upon the perceptual properties of objects and their surroundings a conceptual coordinate system has been established. This occurs about the age of nine years.

According to Piaget (1928) the back-front relationship is established early. The horizontal and vertical axes are later constructed synchronously. Piaget said that conservation of distance which occurs at about the age of seven is prerequisite to the formation of the coordinate system which emerges at the age of nine. Beard (1964) suggested the concept of the vertical precedes that of the horizontal and that development of both concepts proceeds in a piecemeal fashion. Beard's subjects were not at the stage of immediate prediction of horizontal and vertical in all situations by the age of 11 years.

Schantz and Smock (1966) investigated the development of distance conservation and the spatial coordinate system in children aged six to eight years. Their findings confirmed that conservation of distance occurs prior to development of a coordinate system, however, the children in this study seemed to have a coordinate system at a younger age than Piaget's average age.

MacKay et al. (1972) hypothesized that the performance of children on Piagetian tasks designed to investigate the concepts of vertical and horizontal was related to the "difficulty" or "easiness" of the task. Eighty-one children of normal IQ divided into three groups with average ages of seven, eight and nine years were tested with drawing sheets giving two tests of horizontality, one designated easy, the other hard, and two tests of verticality similarly designated. Results indicated that below the level of Piaget's Substage IIIB (In which the construction of the vertical and horizontal is formulated in operational terms and is applied directly to all situations) the children had difficulty in the application of concepts of vertical and horizontal in particular situations. Whether apparent understanding of the vertical precedes that of horizontal or vice versa is determined by the nature of the task. The age at which children reached Stage IIIB in the MacKay et al. research was well beyond the age of nine.

Not unexpectedly, Piaget's description of rather clear cut stages in the development of sensorimotor and representational space and his conclusions regarding the sequential acquisition of

topological, projective and Euclidean spatial concepts have become highly controversial topics and they have generated a great deal of research.

Dodwell (1963) investigated a number of spatial concepts (topological, projective and Euclidean) in 194 children in kindergarten and grades one, two and three. The inter-relationships between the various tasks and differences among the various age groups were assessed. Dodwell observed the sorts of behavior described by Piaget as characteristic for certain ages and stages of development. He found that the overall ability to deal correctly with spatial concepts improved with age. He could not, however, categorize the majority of children studied as being in any one particular stage of spatial concept development described by Piaget.

In the Laurendeau and Pinard (1970) study a number of spatial tasks were given to 50 children at each age level from two to twelve years. They noted irregular performance in individual children across related tasks for a considerable length of time. The horizontal differentials are the "decalages" that Piaget often mentions. In the introduction to Laurendeau and Pinard's (1970) book Piaget explained "decalages" or nonsynchronous acquisitions of concepts which are based on the same operatory structures. He said that "decalage" is analogous to friction in physics. Some objects produce more resistance to symbolic manipulation than others. The resistances are unpredictable. When one encounters them, one can explain them but always after the event. The Laurendeau and Pinard

(1970) study of Piagetian spatial tasks probably is the most comprehensive that has been made to date. After appraisal of the relevant correlation coefficients and the scalogram analyses, the conclusion was reached that there is a consistency or coherence in the way particular spatial concepts are reached. The task stages were achieved in a regular, not a chance order.

CHAPTER II

REVIEW OF RESEARCH: APPLICATIONS OF PIAGETIAN NOTIONS

Piagetian tasks may be helpful in determining whether learning disabilities in specific academic areas or learning disabilities associated with disturbed emotional behavior are related to specific dysfunction in the development of logico-mathematical and spatial concepts. For many years in North America the child's ability to achieve in school was associated almost exclusively with the score obtained in a standard intelligence test. During the past several decades a number of investigators have indicated that successful performance on various Piagetian tasks is a prerequisite for achievement in various school subjects particularly arithmetic and reading. Several comprehensive studies have related performance on Piagetian tasks and emotional stability in children. It is important, therefore, to consider: (1) whether the standard intelligence tests and Piagetian tasks are really measuring different abilities in the child or whether they are tapping the same intellectual resources; (2) the ability of Piagetian tasks to predict academic achievement particularly in arithmetic and reading; and (3) the association between performance on Piagetian tasks and emotional stability. It is necessary to determine whether present assessment procedures need to be modified or broadened.

The Assessment of Cognitive Ability with Piagetian Tasks and Standardized Intelligence Tests.

Kaufman (1972) investigated the psychometric properties of various Piagetian tasks, the Gesell School Readiness Tests and the Lorge-Thorndike Intelligence Test. The inter-relationship of these tests was studied and in addition the factor structures of the Gesell tests and the Piagetian tasks as well as the joint structure for the three tests were analysed. One hundred and three children aged five to six years (IQ range 75-145) were administered the Lorge-Thorndike Intelligence Test (L-T), the Gesell Tests (GSRT) and a Piagetian Battery (PB) that included conservation, classification, seriation and space tasks.

Correlation of the GSRT and PB total scores indicated a substantial relationship between the two tests. Correlations among the total scores of the GSRT, PB and L-T yielded almost identical values and Kaufman concluded that each is an equally good measure of what is common to them but that each has some degree of specificity. Factor analysis of the PB yielded three factors: Number (included numeration, addition and subtraction and conservation of number tasks), Logic (included classification and seriation tasks) and Cognition of Size Relations (included insertion, seriation and conservation of length). Kaufman suggested that these three factors seem to correspond to fundamental logico-mathematical operations, "number," "classes" and "relations" which develop according to Piaget between the sensorimotor and concrete operational stages. Joint

analysis of the PB, GSRT and L-T yielded four rotated factors. Factors I, II and III were very definitely GSRT, PB and L-T general or test factors respectively. However Factor IV was an Academic Achievement factor which resembled both the academic achievement factor derived from the GSRT analysis and the logic factor derived from analysis of the PB.

Kaufman concluded:

> .... To Piagetians, the separate PB and L-T factors suggest that the ability to think logically in a Piaget-type experimental situation is at least somewhat distinct from the ability to score high on conventional, empirically derived, intelligence tests.
>
> (p. 1359)

Stephens et al. (1972) used factor analysis to assess the relationship between a battery of 27 Piagetian tasks (which included conservation, correspondence, classification, space and formal operation tests), the Wechsler Intelligence Scale for Children (WISC), the Wechsler Intelligence Scale for Adults (WAIS), the Wide Range Achievement Test (WRAT) and Warner's Index of Social Characteristics. The tests were administered to a population which included 75 mentally retarded subjects (IQ 50-75, WISC or WAIS) and 75 normal subjects (IQ 90-110, WISC or WAIS). The ages of the subjects ranged from six to eighteen years. The study resulted in the isolation of five factors. Major loadings which contributed to Factor 1 were 13 Wechsler variables, 3 WRAT variables and only one Piagetian task showed a loading of .25 or more. Factor 2 was called the Operational Thought factor. Twenty-three of the Piagetian tasks

showed positive loadings above .25. In addition, chronological age and mental age loaded on this factor and indicated developmental influences. Factor 3, the Classificatory Thought factor, was defined by tasks involving hierarchical class inclusion and afforded some justification for Piaget's distinction between ability in categorization and conservation and spatial orientation. Factor 4 was defined by Piagetian measures of spatial operations (rotation of squares, changing perspectives, coordination of perspectives). Loading of chronological age and mental age on this factor indicated the possible influence of maturation on the ability to anticipate the position of objects as they are rotated in space. Factor 5 was defined as a separate Wechsler visual perceptual synthesis factor. Stephens et al. concluded: "Review of the factor matrix indicated that Piagetian reasoning tasks involve abilities separate from those measured by standard tests of intelligence and achievement" (p. 347).

Hatheway and Hatheway - Theunissen (1974) carried out a comprehensive longitudinal study employing factor analysis to investigate among others the contribution of Piagetian measures to the prediction of school achievement. A total of 104 children yielded at least partial data in kindergarten, grade one and grade two on 21 psychometric variables from the Wechsler Intelligence Scale for Children (WISC) and the Lorge-Thorndike Intelligence Test (L-T), 10 Piagetian variables and in grades one and two 10 scholastic achievement variables on the California Achievement Test (CAT). Three main factors emerged which differed in variable loadings for

kindergarten, grade one and grade two. The factors were defined as follows: Factor 1, General psychometric and verbally mediated intelligence; Factor 2, Piagetian operational intelligence; and Factor 3, Piagetian experiential, logical-classification, seriation and achievement intelligence. The authors interpreted their findings as follows:

> ... there is a moderate positive and statistically significant relationship between the traditional psychometric and the Piagetian measures of mental development ... while both types of measures contribute to a first "general psychometric and verbally mediated intelligence" factor, this aspect of mental functioning is largely defined by the psychometric measures... The existence of the second (Piagetian) factor of operational thought suggests, however, the uniqueness of the Piagetian tasks and the aspects of mental development they reflect. The existence of the third (Piagetian) experiential, logical classification, seriation and education factor suggests the richness as well as the uniqueness of the aspects of a child's thought processes that we may approach by Piagetian means...
> (p. 323)

The foregoing investigations indicate that standardized intelligence tests and Piagetian tasks do indeed sample different aspects of the child's intellectual capacity. It should be remembered, however, that these test procedures were originally designed for different purposes. The intelligence test generally measures language ability, memory, reasoning ability and often perceptual-motor coordination. The standardized intelligence test is used to rank individuals of a given age as to their relative intellectual ability. The Piagetian tasks were designed to study the developmental nature of the child's intellectual growth and to probe the manner in which various concepts were attained.

> ... Piaget's efforts now make it possible to think of measurement arrangements in which logical networks determine the interpretation of a child's set of responses instead of relying on empirical comparisons of the responses of many children.
>
> (Green in Green et al., 1971. p. 219)

The Ability of Piagetian Tasks to Predict Academic Achievement.

Piagetian tasks as predictors of arithmetic achievement.

To deal adequately with basic mathematical concepts the child must be able to conserve, classify, perform serial ordering and grasp the concept of space and spatial representation (Piaget, 1952; Piaget and Inhelder, 1956). A number of studies have related these abilities, particularly conservation and classification, to children's progress in arithmetic.

Dodwell (1961) found a significant correlation (.59) between scores on a Piagetian group test for conservation of number given to kindergarten children and their scores in grade one on a specially designed, teacher-made test for achievement in arithmetic. In 1962 Hood used a battery of Piagetian number and classification tests to determine the presence or absence of pre-number concepts in normal and retarded children. Classroom teachers rated the arithmetic ability of these same children on a scale ranging from grade one to grade five. Hood concluded:

> .... at least an elementary degree of arithmetic may be expected from many children who have still not acquired Piaget's pre-number concepts, but at the same time we find no case of a Stage 1 (pre-operational) child being in Grade 5; although under favorable circumstances such a case may be found, it seems probable that as a general rule more advanced work than the level of grade 4 will increasingly demand these

> concepts. One should not expect a child of predominantly Stage 1 responses to go far in arithmetic, and there is a strong case for regarding presence or absence of the concepts as the main factor in weighing up a child's readiness on the intellectual plane.
>
> (p. 280)

Both the Dodwell (1961) and Hood (1962) studies were criticized for using teacher-made tests and teacher evaluations to estimate arithmetic achievement. In this connection it is interesting to consider the Dudek et al. (1969) research. Piagetian tasks of conservation, space and causality were administered to kindergarten and grade one children. Results were correlated with both total performance on the California Achievement Test and teacher marks in grade one and two. Correlation values obtained for kindergarten to grade one were .59 (CAT) and .42 (teacher marks). Values obtained for grade one to grade two were .63 (CAT) and .50 (teacher marks). The correlation of the Piagetian tasks with the standardized test is of greater significance in each case, however, the correlation between the same tasks and the teacher marks cannot be discounted.

Almy et al. (1966) reported moderate correlation between conservation abilities in kindergarten and arithmetic achievement in the second grade as measured by two parts of the New York Inventory of Mathematical Concepts. Correlations of .26 and .53 were reported for middle class children and values of .41 and .38 were reported for lower class children. Freyberg (1966) administered a Piagetian group test of conservation, class inclusion and causality tasks to children aged five to seven years. Two years later these scores were

correlated with the results obtained by the same children on an arithmetic achievement test. Values reported were .52 (computation) and .57 (problem solving). Stommel (1966) and Wheatley (1967) reported correlations between first grade conservation scores and end of the year arithmetic achievement of .85 and .86 respectively. Wheatley (1968) investigated the importance of conservation as a predictive index of arithmetic achievement. He administered tasks from the Greater Cleveland Mathematics Programme, the Number Concept Test and the Stanford Achievement Test. Correlation of results revealed conservation to be the best single predictor of mathematics achievement.

Goldschmid and Bentler (1968a) developed the Concept Assessment Kit and studied conservation skills in a large group of young children. They reported a significant positive relationship (.52) between these abilities and arithmetic achievement. Correlation of conservation skills with progress in science, social studies, music and handwriting did not yield such significant results. Bearison (1974) related the conservation scores of kindergarten children to their performance on the Stanford Achievement Test (SAT) in grade three. He concluded that conservation was a good predictor of achievement in arithmetic conputation and arithmetic concepts and in verbal skills (word study skills, word meaning and paragraph meaning). Conservation was not a good predictor of achievement in spelling, science, social studies and language on the SAT. Bearison suggested that the relation of conservation to some areas of

attainment and not to others is consistent with Piaget's distinction of the figurative and operational aspects of knowledge.

> ... Skills such as spelling, vocabulary and punctuation have to do with the encoding and decoding of verbal symbols, what Piaget refers to as the "semiotic" and communicative function of thought ... but they do not reflect operational intelligence per se. It is therefore fitting that a test for conservation, as a measure of the presence of concrete operations in the child, would predict essentially the operational aspects of school achievement and not the figurative aspects.
> (pp. 239-240)

Cathcart (1971) working with second and third grade pupils found that children who employed varied rationalizations for conservation operativity achieved a higher level of mathematics success than those who advanced only one explanation. It was suggested that the ability to analyse a problem from various points of view may be essential for success in mathematics. Kaufman and Kaufman (1972) tested 80 kindergarten children with the Gesell School Readiness Tests, a Piagetian Battery of number, logic and space tests and the Lorge-Thorndike Intelligence Test. Academic achievement was measured for the same children at the end of first grade with the Stanford Achievement Test. The Piagetian Battery was equal to or superior to the other tests in predicting academic achievement. The correlation of Piagetian subtests with arithmetic achievement were: length .29, conservation of number .47, ordination and coordination .56, straight line .39 and logical classification .34.

In the Hatheway and Hatheway - Theunissen (1974) study cited previously, various combinations of psychometric, Piagetian and achievement variables were used to derive the three major factors at

different grade levels. Of particular interest here was the use of ten WISC variables, nine Piagetian variables and six CAT variables (for arithmetic, spelling and reading) to derive Factor 3, Piagetian experiential, logical-classification, seriation and achievement intelligence in grade one and grade two. In grade one highest loadings were for Piagetian number, inclusion and seriation tasks, WISC arithmetic and all the CAT subtests on reading, arithmetic and language. The WISC information, similarities and picture arrangement variables gave moderate loadings and a low loading of Piagetian conservation of quantity was noted. In grade two, very high loadings were found for WISC arithmetic, block design, mazes and object assemblies, high loadings for Piagetian inclusion and seriation tests and the six CAT subtests had their overwhelmingly greatest loadings on this factor. Correlation between the total CAT arithmetic score and the Piagetian battery was .68 at the grade one level and .66 at the grade two level. Regarding the correlation for the individual tests in the Piagetian Battery with arithmetic the highest values were reported for the space test at both grade levels.

It is perhaps fitting to close this summary of the relation between performance on Piagetian tasks and achievement in arithmetic with a comment from Piaget (1972):

> ... if mathematics teachers would only take the trouble to learn about the "natural" psychogenetic development of the logico-mathematical operations, they would see that there exists a much greater similarity than one would expect between the principal operations spontaneously employed by the child and the notions they attempt to instil into him abstractly.
> (p. 18)

Piagetian tasks as predictors of reading achievement.

David Elkind has carried out extensive investigations of the role of perception in reading. Elkind's work has been based on Jean Piaget's (1961) developmental theory of perception. Unlike the development of intelligence which according to Piaget is marked by qualitatively distinct stages that are related to age, perception develops on a continuous basis and is assessed quantitatively not qualitatively. Elkind (1969) has succinctly summarized Piaget's theory of perception:

> ... The perception of the child is "centred" in the sense that it is caught and held by the dominant aspects of the visual field. In each case, the dominant aspects of the field are determined by Gestalt-like features such as continuity, proximity and closure which Piaget speaks of as "field effects". With increasing age, however, and the development of perceptual activities (internalized actions), the child's perception becomes increasingly "decentred" in the sense that it is progressively freed from its earlier domination by field effects ... for Piaget, perception in the young child is primarily determined by peripheral sensory processes whereas in the older child and in the adult, central nervous processes come to play the leading role in what is perceived.
>
> (p. 198)

For Piaget, perceptual activities include exploration, reorganization, schematization, transport and anticipation. These diverse processes which probably are present in some vestigial form at birth "do not appear all at once but seem to emerge in a sequence which is related to age" (Elkind, 1967, p. 358). The "decentering" of perception comes about in middle childhood. It is important to stress that a child may, for example, at a given time be more

"decentered" with respect to exploration than with respect or reorganization.

> ... the extent to which a subject can decenter in any given situation is always a joint function of the level of maturity of the perceptual activities, in question and the nature of the stimulus itself. For those configurations where field effects are strong, decentration may appear at a later age than it will for those configurations where the field effects are weak.
>
> (Elkind, 1967, p. 358)

The mental rearrangement of a stimulus or pattern without acting physically upon it, is called perceptual reorganization (Elkind, 1969). For example, the letters "lube" can be mentally unscrambled and the color word "blue" identified. Figure-ground reversal involves a similar process. Elkind and Scott (1962) quoted an example from Piaget to show how logic is involved in perceptual reorganization. This perceptual activity is in some respects similar to the process of logical multiplication which emerges in middle childhood. The reader is asked to consider a line drawing of a circle on a white card. The enclosed area is represented by EA, the surrounding area by SA, the contour by C, the figure by F and the ground by G.

> ... to perceive the contour line as a circle on a white field, the child must perform the following operations EA + C = F; SA - C = G ... to perceive the contour line as the edge of a hole in a white screen the child must perform the following operations EA - C = G: SA + C = F ... perceptual operations are never completely reversible (capable of all possible reorganizations) ... SA - EA = C is a meaningful operation to intelligence but an impossible operation for perception because the result cannot be perceived.
>
> (p. 619)

According to Piaget, the ability to spontaneously reverse figure and ground appears gradually with increasing age. Elkind and Scott assessed the ability of nursery and elementary school children to perceive both forms in a set of ambiguous figures. Their results indicated that "success in perceiving ambiguous figures varied significantly with age, with the articulation of the drawings and with IQ" (p. 627).

Elkind has suggested that perceptual reorganization has particular relevance for the teaching of English phonics. To learn phonics a child must realize that one and the same letter can represent more than one sound and that the same sound can be represented by different letters. This could be considered analogous to the problem of reversing figure-ground when viewing an ambiguous figure and also to logical multiplication wherein a new class is formed from two independent classes that overlap with respect to their membership. "It would seem necessary from the standpoint of the perceptual decentration theory, for the child to logically multiply all sound and letter combinations and from the resulting combinations choose those that are operative in English" (Elkind et al., 1965, pp, 51-52).

Housch (1972) also related the ability of multiplicative classification to the learning of grapheme-phoneme correspondences. Garrettson (1971) found a significant and positive relationship between the performance of 60 boys (aged seven to eight) on the

Metropolitan Reading Achievement Test Primary I Battery and scores obtained on Piagetian matrices tasks (.30) and inclusion tasks (.41).

Elkind et al. (1965) compared the ability of slow (one to two years below grade level) and average elementary school readers matched for age, sex and nonverbal IQ to perceive hidden figures on a set of ambituous figures. The children were then trained to detect such figures on a second comparable set of pictures and then retested on the first set. The slow readers were deficient in figural decentration compared to the average readers and did not display significant transfer of training effects. These results supported the hypothesis that the ability to "decenter" perception is involved in the reading process. The more "decentered" a child's perception, the better his reading ability. Since the slow and average readers had been matched for IQ, Elkind et al. suggested that "ability to decenter perception is not the same as general intelligence measured by a nonverbal test" (p. 55). The authors drew a final conclusion:

> ... a simple discrimination theory of perception is not adequate to deal with the problem of learning the symbols of English phonics and that the role of 'perceptual activity' - mental manipulation of perceptual givens - will have to be taken into account to fully describe the role of perception in reading.
>
> (p. 56)

Perceptual schematization involves "the coordination of wholes and parts in such a way that both retain their unique identity without losing their inter-dependence" (Elkind, 1967, p. 358). Part-whole perception in young children aged four to nine years was studied by

Elkind et al. (1964). The activity was assessed by means of drawings in which whole figures were made of parts with independent meanings. Conclusions reached were that the ability to perceive parts and wholes increases with age; parts were perceived at an earlier age than wholes and the majority of the children (75 percent) had achieved part-whole integration by the age of nine. Elkind (1969) suggested that part-whole perception can be related to the logical multiplication of classes described by Piaget. Elkind raised questions regarding the Look-Say method of reading which teaches whole word recognition without analysis of parts:

> Successful reading ... would seem to require a true whole-part schematization: a good reader must be aware both of the independence of the individual letters and of the whole word while remaining cognizant of their interdependence. Only a true whole-part schematization of words will enable the child to spontaneously discover and recognize new words.
> (Elkind, 1967, p. 359)

Elkind (1969) suggested that dealing with prefixes, suffixes, tenses and plurals involves schematization.

The systematic scanning of an array or pattern so as to note all of its particular features involves perceptual exploration (Elkind, 1969). The manner in which children aged five to eight years scanned pictorial arrays which differed in degree of strong Gestalt qualities such as continuity and closure was explored by Elkind and Weiss (1967). They found:

1. The exploration of an unstructured stimulus array became more systematic and increased in complexity with increasing age.

2. The exploration of a structured array was systematic at all age levels tested although the pattern of exploration varied at successive age levels. (p. 559)

These findings supported Piaget's hypothesis that "decentration" of perception is due to interaction of the level of maturity of the perceptual activities and the nature of the stimulus. Elkind (1969) related perceptual exploration to the logical process of seriation described by Piaget. Successful scanning of an unstructured pictorial array requires the organization of a serial order of the various pictures. With respect to reading: "The ability to construct spatial seriations ... is clearly essential for comprehending the grammatical significances of word order" (p. 202).

Transport according to Elkind (1969) involves the ability to transfer visual stimuli over space and time and anticipation refers to the ability to infer a logical sequence of various syntactic and semantic forms. Adequate comprehension and effective rapid reading depend on the ability to transport and anticipate meanings among words and sentences (Elkind and Deblinger, 1969). Extensive full-scale research in the areas of transport and anticipation has not been carried out by Elkind.

Elkind's investigations of perceptual reorganization, schematization and exploration provided support for Piaget's theory of perceptual development. The performance of the children was

determined by interaction between the nature of the stimulus configuration (strength of "field effects") and the "level of maturity of the children's perceptual activities". Many times it was observed that children who performed well on the "perceptual activity" tests were better readers than those who did poorly. It was also noted that training in "perceptual activities" led to improved performance (Elkind et al., 1965).

Millie Almy also looked at the development of the reading process in the light of Piaget's theory. She suggested:

> ... the roots of reading can be traced in the sensori-motor period of infancy (0-2) to the developing pre-requisite of the semiotic function. At around age two the child is developing the ability to use mental images to represent reality. Just as the child who is learning to speak acquires a system in which a word signifies an internal representation, so the child learning to read must attach the representation to a new visual sign.
>
> (Almy (1972) cited by Foorman 1974, p. 182)

Almy et al. (1966) found moderate correlation between conservation scores obtained by kindergarten children and their reading achievement in the second grade as measured by the New York Test of Reading Readiness and Growth. Correlation between conservation and readiness was .53 for middle class children and .39 for lower class children. Correlation between reading growth and conservation was .37 for middle class children and .39 for lower class children. Bearison (1974) reported significant correlation between the conservation ability of kindergarten children and their achievement with respect to verbal skills (word study skills, word meaning and paragraph meaning)

as measured by the Stanford Achievement Test in grade three. Kaufman and Kaufman (1972) reported a correlation of .58 between a Piagetian Battery of number, logic and space tests and reading achievement on the Stanford Achievement Test. Hatheway and Hatheway - Theunissen (1974) found a correlation between a Piagetian Battery of number, logic and space tests and total reading score on the California Achievement Test of .54 in grade one and .57 in grade two. Considering the correlation of the individual Piagetian tasks with reading vocabulary and comprehension the authors reported the highest correlation between the seriation task and vocabulary and comprehension at the grade one level, however, the spatial task showed the highest correlation with reading vocabulary and comprehension at the grade two level. Recently Brekke and Williams (1975) assessed 81 grade one children for reversibility and conservation using five Piagetian tasks. Children who demonstrated both conservation and reversibility obtained higher reading readiness scores as measured by the Gates McGinitie Reading Tests of Readiness Skills. In an excellent study, Klees and LeBrun (1972) demonstrated that dyslexic children display general retardation in the acquisition of operative mechanisms. Dyslexics were delayed by one year compared to normal children in the acquisition of conservation. The same was true of performance on seriation tasks. Dyslexic children were very inferior in acquiring the notion of inclusion of classes.

Spatial orientation deficits and reading difficulties have also been linked. Harris (1957) found that slow readers were less able than capable readers of the same age to discriminate left and right on their own bodies. However, Harris reported that the difficulty was observed at the age of seven and had disappeared by the age of nine. Benton's (1959) research seems to indicate that instances of systematic reversal are more common among poor readers than instances of basic left-right confusion. Coleman and Deutsch (1964) gave tests of lateral dominance and of left-right discrimination to children aged 9.5 to 12.3 years. Normal and slow readers were included in the group. No significant differences between the groups were reported. They also found no significant differences with respect to the occurrence of systematic reversals in the two groups. Lovell, Shapton and Warren (1964) also worked with older children (average age 9.8 years) and unlike Coleman and Deutsch they did find significant differences between the ability of good and poor readers to discriminate left and right on their own bodies. Kershner (1975) investigated the development of conceptual spatial ability and visual perceptual ability in seven year old children and related such development to their reading ability. He found no significant differences in reading ability when children were grouped according to perceptual ability. However, when the children were grouped according to performance on a cognitive spatial test significant differences in reading ability were detected. Superior reading ability was related to high performance on the cognitive spatial task.

<u>The Relationship Between Performance on Piagetian Tasks and Emotional Maturity</u>.

Piaget discussed the simultaneous development of cognitive and affective activities in a series of three lectures delivered at the Menninger Clinic in Topeka, Kansas, in 1962.

> ... in all behavior the structure is cognitive, and the force or economy is affective. Therefore affect cannot be the cause of a cognitive structure, anymore than intelligence can be the cause of affect, because a structure is not the cause of this energy, this force and vice versa. Between the two is a relation of correspondence, and not of causality.
>
> (Piaget, 1962b, p. 131).

Further to this Piaget (1962b) said:

1. schemata of objects and persons exist constantly in the cognitive relations of the child - these schemata are always both affective and cognitive at the same time.

2. the schemata related to persons have both a cognitive and affective aspect, since persons are the centers of causality and the sources of all kinds of cognitive ideas as well as feelings.

Hill (1972) questioned Piaget about the association between intellectual and emotional development and mentioned Piaget's failure to present actual data concerning the relationship. At that time Piaget's reply was:

> Emotional development is the driving force. Intelligence does not work without affective motivation. That's clear. By the affective aspect emotions are modified by the structures of intelligence. The energy factor is the driving force. Then there are the structural factors. It is the structure which interests me, not the driving force ... as an investigator the problem of knowledge has interested me.
>
> (Piaget, cited by Hill, 1972)

Thus, Piaget has left it to others to investigate the link between affective and cognitive development and a number of researchers have studied intellectual development in children experiencing emotional behavior difficulties.

In 1967 Goldschmid compared the performance of normal seven year old children and emotionally disturbed nine year old children on Piagetian conservation tasks. The latter, who were on the average two years older than the normal children, were at about the same level of conservation. Goldschmid (1968) again compared normal and emotionally disturbed children with respect to conservation ability. In addition, he assessed their performance on the Children's Manifest Anxiety Scale. Actual and ideal self ratings, teacher's rating, socio-metric choice, parental attitude surveys and IQ scores were obtained. He concluded that generally children who demonstrated a high level of conservation were: (1) more objective in their self evaluation, (2) described more favorably by teachers, (3) preferred by their peers, (4) less likely to be dominated by their mothers and (5) generally considered more attractive and passive than children who performed poorly on conservation tasks.

Possible empirical links present among cognitive, affective and environmental factors in the child's development were investigated by Modgil (1969). A number of variables were assessed for groups of emotionally stable and emotionally unstable seven year olds. The cognitive variable selected was the Piagetian concept of

conservation. Affective variables consisted of (a) the child's emotions as measured by the Bristol Social Adjustment Guides (Scott, 1958) and the Rutter Scales (1967-1968); (b) anxiety as measured by an adaptation of Sarason's GA and TA Scales (1958) and (c) the child's conceptualization of his actual self as measured by an adjective check list. Among the environmental factors chosen were (a) the child's attitudes to arithmetic, school and teacher; (b) teacher ratings of the child and (c) parental attitudes towards child rearing as measured by the Parental Attitude Survey (Shoben, 1949). In all 29 variables were correlated and factor analysed. Results indicated:

> 1. Emotionally unstable or disturbed children develop conservation later than normal stable children of the same mental age. Emotional stability and social order have a facilitating effect on cognitive functioning.
>
> 2. Children who have a high level of conservation tend to see themselves more objectively and are more reflective.
>
> 3. Children who score high on conservation tasks tend to possess parents with less dominating, ignoring, possessive attitudes.
>
> 4. Over and above the association of low conservation with unfavorable parental attitudes there is a specific association with high dominance.
>
> 5. There was little evidence that a child's positive attitudes to arithmetic, school and the teacher have facilitative effects on conservation.
>
> (Modgil (1969) cited in Modgil 1974, p. 377)

Recently (Lester et al., 1970; Dudek, 1972 and Dudek and Dyer 1972) conducted a four-year longitudinal study among 100 school children in Montreal. They administered an extensive battery of

psychological tests including Piagetian tasks (conservation, classification, seriation, space), the Cattell Early School Personality Questionnaire and the Rorschach Test. The study reported excellent justification for the authors' hypothesis that children who showed a faster rate of intellectual maturation would be more mature, stable and emotionally healthy.

Pimm (1974) conducted several interesting investigations that related performance on Piagetian conservation tasks to emotional behavior problems in children. In one study the conservation skills of emotionally disturbed children from special classes were compared with those of normal children, of the same age. A second study investigated conservation ability in three groups of children at different age levels who had scored above the 90th percentile on the Ottawa School Behavior Check List, a screening device for identification of emotionally disturbed children, (Pimm and McClure, 1967). Results indicated that normal children perform at a higher level of conservation than emotionally disturbed children of the same age. The emotionally disturbed children in the two studies did not differ significantly in their lack of conservation skills. Pimm noted in her studies that the emotionally disturbed children appeared to be more egocentric than the normal children. Piaget (1950) suggested that an inability to "decenter" may underly the child's failure to conserve. Pimm (1974) suggested that the emotionally disturbed child does not behave appropriately towards others because he fails to discriminate role attributes of others.

> ... Information reaching the child is assimilated only in terms meaningful to himself. Others are not separate entities, they are defined only in terms of their relationship to him. Cooperation is seen by Piaget as being the antidote to "egocentrism". However, Piaget's cooperation demands that the child be able to distinguish his own desires as separate from the external world and from the wishes and expressions of others.
> (pp. 202-203)

Neale (1966) investigated egocentrism in institutionalized and non-institutionalized children. Considering Piaget's view that egocentrism is broken down by the socialization process and admitting that extremely poor socialization is an aspect of the emotionally disturbed syndrome, Neale hypothesized that emotionally disturbed children would show greater egocentrism than a normal control group. Emotionally disturbed children (aged eight to eleven) were compared with normal children matched for chronological age, mental age, IQ and sex. Piaget's "three mountain" task was selected to measure egocentrism. At all age levels the emotionally disturbed children were significantly more egocentric. Recently, Rubin (1973) investigated egocentrism in children in kindergarten and grades two, four and six. Communicative, cognitive (private speech), role-taking and spatial egocentrism as well as IQ and conservation abilities were measured. Factor analysis revealed a single "decentration" factor reflecting the high inter-relationships between role-taking, communicative and spatial egocentrism and conservation. The loading of mental age and chronological age on the factor suggested that experience acquired with age facilitates decentration.

Difficulty in grasping the concept of object permanence has been associated with poor performance on Piagetian tasks by emotionally disturbed children (Anthony, 1956, 1966; Bell, 1968; Dasen et al., 1972). Lefebre (1970) reported an interesting case of an emotionally disturbed boy (age, 10 years 6 months; Binet IQ, 90) who was experiencing severe academic problems. Using a battery of Piagetian tasks to assess his cognitive ability, Lefebre found the boy to be functioning at the six year level on logico-mathematical and spatial tasks. Lefebre attributed the difficulty partly to two years of multiple foster home placement during the boy's early childhood. It was suggested that due to the multiplicity of maternal figures that appeared and disappeared in his existence, the boy had not been able to grasp the notion of object permanence. Training in the concepts of equality, disequality and classification along with role-playing experience led to improved academic performance.

Several conclusions may be drawn from the research which has been summarized in this chapter. The addition of Piagetian tasks and Piaget's "methode clinique" to present assessment procedures, which rely heavily upon information from standardized psychometric tests, should favorably enhance our knowledge of the individual child's capabilities. The use of Piagetian tasks to predict academic achievement seems justified. The tasks would appear to yield reliable and helpful information as to the child's ability to succeed in both arithmetic and reading. The probability of a link between

performance on various Piagetian tasks and emotional stability provides support for using these tasks in exploring the nature of emotional disturbance as well as academic disability.

CHAPTER III

THE STUDY

The research reviewed in the preceding chapter seemed to provide adequate evidence to support the following statements:

1. Piagetian tasks do to a significant extent measure cognitive abilities which differ from those assessed by standardized intelligence tests.
2. Piagetian tasks provide reliable prediction of academic achievement in reading and arithmetic.
3. Poor performance on Piagetian tasks is associated with emotional behavior problems in children.

Few studies have looked at groups of children which had been initially selected on the basis of demonstrated learning disabilities. The purpose of the present investigation was to study the development of logico-mathematical and spatial concepts in children at two different age levels, with average intellectual potential, whose learning disabilities were manifested by deficits in reading or arithmetic or emotional behavior problems.

The sample population identified for the investigation included a group of control children who were experiencing no academic or behavioral problems, and five groups of children who demonstrated learning disabilities associated with academic and/or emotional behavior. The groups involved in the study were as follows:

1. control subjects with no academic or behavior problems.
2. reading underachievers only, no severe behavior problems.
3. arithmetic underachievers only, no severe behavior problems.
4. underachievers in both reading and arithmetic, no severe behavior problems.
5. underachievers in reading and arithmetic with behavior problems.
6. subjects achieving academically who were experiencing sufficient behavior problems to necessitate their exclusion from the regular school class.

Two groups for each of these categories of learning disabled and control children were included in the study: one group below a chronological age of 9 years and 6 months and one group above that chronological age. The inclusion of two different age levels in the study was based on the findings of recent investigators. Sabatino and Hayden (1970) after administering a psycho-educational test battery to children failing in the elementary grades suggested, "young children depend more upon perceptual skills as an isolated source of mutual learning, while older children can compensate with language for poorly developed perceptual behaviors" (p. 49). Other investigators (Bryden, 1972; Denney, 1974; Jorgenson and Hyde, 1974) reported similar findings with respect to the developmental pattern of

auditory visual integration skills in children. Whyte (1967) reported significant differences with respect to the relative importance of certain abilities measured by Piagetian tasks among children of different IQ levels.

Satz et al. (1971) tested language and nonlanguage skills in average and disabled readers aged seven to twelve. They concluded:

> 1. The age factor is a critical independent variable which should be examined in investigations of specific reading disability.
>
> 2. "... an earlier delay in maturation may forecast behavioral immaturity at each successive stage of hierarchical development. Thus, while the child who lags in visual-motor integration at age 7-8 may eventually "catch up" by age 11-12, he may now lag in those skills (e.g., symbolic language) which have a later ontogenetic development.
>
> 3. ... identification of delays in maturation at earlier ages (e.g. preschool) may provide valid predictors of later reading disability.
>
> (pp. 2018-2019)

Selection Criteria for Subject Identification and Description of the Sample.

Children at and below the chronological age of nine years six months were chosen primarily from grade three classes on the basis of their grade two scores on the Stanford Achievement Test (SAT) for reading and the Edmonton Public School Board (EPSB) test for mathematics and their grade three IQ scores on the Canadian Cognitive Abilities Test (CCAT). Children in categories 1 (control), 2 (reading disability), 3 (arithmetic disability) and 4 (reading and arithmetic disability) in this age category were selected in the following way.

A potential reading problem was initially identified when a child obtained a score at or below the tenth percentile on the word study skills section of the SAT. If the arithmetic score in this case was above the 30th percentile on the EPSB test the child was considered to have a reading disability but to be performing within a normal range in arithmetic for his/her grade level. A nonverbal score of 85+ on the CCAT was considered indicative of normal intellectual ability for each of the groups included in this chronological age range. Since the children involved in the study were thought to be experiencing logico-mathematical and spatial deficits, the nonverbal score was used in order not to penalize them in these areas.

A potential arithmetic problem was initially identified when a child scored at or below the tenth percentile on the EPSB test. If a score above the 30th percentile was obtained on the word study skills section of the SAT the child was considered to have an arithmetic disability but to be performing within a normal range in reading for his/her grade level.

Potential disability in both reading and arithmetic was initially associated with scores at or below the tenth percentile on both of the academic achievement tests.

The control group of children was selected on the basis of scores above the 30th percentile on both tests.

Children above the chronological age of nine years six months were chosen primarily from grade six classes on the basis of their grade five scores on the Stanford Achievement Test (SAT) for reading

and the Edmonton Public School Board (EPSB) test for mathematics and their grade six IQ scores on the Lorge Thorndike Intelligence Test (LT). Children in categories 1 (control), 2 (reading disability), 3 (arithmetic disability) and 4 (reading and arithmetic disability) in this age category were chosen in the following way.

A potential reading disability was initially identified when a child scored at or below the tenth percentile on the paragraph meaning section of the SAT. If the arithmetic score in this case was above the 30th percentile on the EPSB test the child was considered to have a reading disability but to be performing within a normal range in arithmetic for his/her grade level. A nonverbal score of 85+ on the LT was considered indicative of normal intellectual ability for each of the groups included at this chronological age level.

A potential arithmetic problem was initially identified when a child scored at or below the tenth percentile on the EPSB test and scored above the 30th percentile on the paragraph meaning section of the SAT.

Potential disability in both reading and arithmetic was initially associated with scores at or below the tenth percentile on both tests of academic achievement. The control group of children was selected on the basis of scores above the 30th percentile on both achievement tests. In all cases and at both age levels the current academic performance of the children was verified with the

classroom teacher before a final decision to include them in the study was made. Occasionally the academic performance of children selected for the study on the basis of the SAT, EPSB, CCAT and LT tests was considered by the home room teacher to be at grade level. These children were therefore dropped from the study and in several cases children recommended by teachers as fitting the criteria for disability were included in the investigation. A full description of the subjects' age, IQ score, IQ test, achievement tests, scores etc. is included in Appendix C.

At both age levels, children who were underachieving in both reading and arithmetic and who were experiencing behavior difficulties were selected from the Adaptation Classes of the Edmonton Public School System. These classes were designed specifically for such children in order to provide a curriculum and environment that would hopefully enable them to compensate for their learning disabilities and facilitate their return to regular school classes. Performance judged by the home room teacher to be well below expected grade level in reading and arithmetic and a performance IQ of 85+ on the Wechsler Intelligence Scale for Children (WISC) served as the selection criteria for this group.

Children at both age levels who were achieving academically but who had sufficient behavior problems to necessitate their exclusion from regular classrooms were selected from the Emotionally Disturbed Unit of the Glenrose Hospital School in Edmonton. The current academic performance as assessed by the homeroom teacher and

a performance IQ of 85+ on the WISC served as the criteria for selecting these children.

An attempt to identify ten subjects in each category at both age levels was made. After examining the records of approximately 4,000 children most of the subjects were located in 16 different schools. However, it was not possible to identify ten subjects in each category. The numbers of subjects tested in the investigation is outlined in Table 1. The description of the sample by sex, chronological age and IQ is included in Table 2.

TABLE 1

NUMBERS OF SUBJECTS TESTED

	Type of Learning Disability					
	Reading	Arithmetic	Behavior	Reading & Arithmetic	Reading, Arithmetic & Behavior	Control Group
Below nine years six months	10	8	8	9	10	10
Above nine years six months	10	11	9	12	10	10

N below nine years six months = 55

N above nine years six months = 62

Total N = 117

TABLE 2

DESCRIPTION OF SEX, CHRONOLOGICAL AGE AND IQ CHARACTERISTICS OF SUBJECTS

Group	Sex		C.A. Level	C.A. Characteristics			Non-verbal IQ Characteristics			
	M	F		Range (months)	Mean	Standard Deviation	Range	Mean	Standard Deviation	Test
Control	5	5	< 9:6	101-111	105.7	3.06	93-143	106.4	14.88	CCAT, N=10
	5	5	> 9:6	135-149	142	4.88	89-120	118.4	14.71	LT, N=10
Reading Disability	9	1	< 9:6	103-112	108.4	2.55	83-101	93.4	6.06	CCAT, N=10
	9	1	> 9:6	116-150	135.9	11.05	100-153	121.3	22.84	WISC, N= 4
							95-128	112.8	12.60	LT, N= 6
Arithmetic Disability	4	4	< 9:6	88-106	101.3	5.97	85-111	97	9.59	CCAT, N= 7
	7	4	> 9:6	125-168	148.4	12.09	85-109	96.6	10.23	WISC, N= 5
							87-109	99.7	8.57	LT, N= 6
Behavior Problems	4	4	< 9:6	81-111	101	11.33	101-120	109	7.00	WISC, N= 7
	9		> 9:6	120-165	147.8	14.56	78-118	106.1	12.38	WISC, N= 9
Reading and Arithmetic Disability	6	3	< 9:6	99-112	104.6	4.22	100-111	105.5	7.75	WISC, N= 2
							88-108	97.2	8.73	CCAT, N= 6
	5	7	> 9:6	117-152	138.9	10.30	90-111	99.5	9.56	WISC, N= 6
							86-105	94.2	8.20	LT, N =5
Reading, Arithmetic Disability and Behavior Problems	8	2	< 9:6	102-114	109.5	4.01	85-120	99	9.94	WISC, N= 8
	6	4	> 9:6	120-168	143.6	18.19	84-121	100.6	13.33	WISC, N= 8

The Test Battery.

A battery of Piagetian tasks was administered to investigate the development of logico-mathematical (classification and number) and spatial concepts. The battery included the following tests:

A. Mathematical Concepts.

1. Conservation of Number.
2. Seriation.

B. Classification Concepts.

1. Additive Composition of Classes.
2. Multiplicative Classification.
3. Duality Principle.

C. Tests of Spatial Development.

1. Concepts of Left and Right.
2. Localization of Topographical Positions.
3. Coordination of Perspectives.

The Conservation of Number test was developed by Lovell (1961); the Seriation test was that of Almy (1970); the three classification tests (Additive Composition, Multiplicative Classification and the Duality Principle) were developed by Whyte (1967). The three tests of spatial development were devised by Laurendeau and Pinard (1970). The tests are fully described in Appendix A. The tests for logico-mathematical concepts with one exception measure concepts which develop during the preoperational and concrete operational periods and generally during the chronological age range from three to eight or nine years. The test for the Duality Principle includes a concept

whose development extends into the formal operational period. The tests of spatial development cover a developmental period ranging from four years to approximately thirteen years of age (Laurendeau and Pinard, 1970).

Procedure.

The test battery was individually administered to each subject by the writer and the responses recorded verbatim. The tests were administered in a constant order, i.e. Conservation, Additive Composition of Classes, Multiplicative Classification, Seriation, Duality principle, Concepts of Left and Right, Localization of Topographical Positions and Coordination of Perspectives. The stage of development was assessed from the recorded data. A full description of the various test stages is given in Appendix B. For statistical analysis the stage of development was converted to a numerical scale as follows:

Stage of Development	Period of Development	Numerical Value
0	No response, presumably sensorimotor period	1
IA	Preoperational	2
IB or I	Preoperational	3
IIA	Preoperational	4
IIB or II	Preoperational	5
IIIA	Concrete operational	6
IIIB or III	Concrete operational	7
IV	Formal operational	8

Where substages are not included in stage development descriptions, the stage was considered to be at the second level of that stage, for example, in Conservation of Number the stages are I, II, III but in the Concepts of Left and Right the stages are IA, IB, IIA etc.

The developmental stages and numerical scores for all subjects are included in Appendix C. Ten percent of the test protocols were randomly selected for evaluation and assessment by an independent examiner. The percentage of agreement between the original investigator and the independent examiner was 91 percent.

Questions for Investigation.

The study was designed to investigate the following questions:

1. Will the developmental stages described by Piaget for normal children on the various tests of mathematical concepts, classification and spatial development be observed in learning disabled children?
2. Will the sequence of developmental stages proposed by Piaget for mathematical concepts, classification and spatial development be observed in the learning disabled children?
3. Will learning disabled children classified as having reading or arithmetic or behavior problems or reading and arithmetic problems or reading, arithmetic and behavior problems be differentiated by stage of development on mathematical concept tasks?

4. Will learning disabled children classified as having reading or arithmetic or behavior problems or reading and arithmetic problems or reading, arithmetic and behavior problems be differentiated by stage of development on classification tasks?
5. Will learning disabled children classified as having reading or arithmetic or behavior problems or reading and arithmetic problems or reading, arithmetic and behavior problems be differentiated by stage of development on tests of spatial development?
6. Will the older children become operational on the Piagetian tasks but continue to experience academic difficulties?

Analysis of Data.

The data were tabulated to assess the performance of the various groups in terms of stage of development at two age levels for each of the tests. Bar graphs were then prepared depicting the percentage of subjects in each group at each age level who were clearly operational on each of the Piagetian tasks. Inspection of the graphs indicated that some differences might exist between the groups. The quantitative stage descriptions of the subjects in the various groups for each of the tests were then subjected to a one way analysis of variance (ANOV15)* and a Scheffé multiple comparison of means in order to determine whether significant differences between

---

*Program developed by the Division of Educational Research Services, Faculty of Education, University of Alberta.

groups did indeed exist. The IBM 360 Computer was used to analyze the data.

Limitations of the Study.

This study was limited in two major areas. The first involved the selection criteria for the subjects. Since one hour of individual testing time was required to administer the battery of Piagetian tasks, it was not practical to administer common intelligence and achievement tests to all of the participants. It was necessary, therefore, to rely initially upon the accuracy and validity of the test results available from the Edmonton Public School Board and the Glenrose School Hospital and finally upon the teachers' verifications of the subjects' academic performance and emotional status. The second area in which the study was limited involved the small numbers of subjects tested in each category. The results obtained may be useful in indicating trends that exist with regard to the performance of certain groups of learning disabled children on specific Piagetian tasks and thus suggest possibilities for further research in order to verify the results with much larger populations.

CHAPTER IV

RESULTS

The data were analysed as follows:

1. The stage of development for each child on each task was determined and the numbers of children in each category who performed at the various stages were totalled.
2. The percentage of children who were clearly operational on each task was determined and graphs were drawn to show the percentages.
3. A one way analysis of variance (ANOVA) was computed for each of the age levels to determine whether significant differences existed between the group means.
4. A Scheffé multiple comparison of means was computed for each of the age levels to determine which of the groups differed significantly.

The number of children at each stage on each of the various tasks is presented in Tables 3 and 4. Table 3 includes the tasks classified under logico-mathematical concepts. Table 4 includes the tasks classified under spatial development. Each of the tasks will be discussed individually.

TABLE 3

PERFORMANCE OF CHILDREN BY STAGE OF DEVELOPMENT IN THE LOGICO-MATHEMATICAL TASKS

Group	C.A. Level	N	Number Conservation			Seriation				Multiplication of Classes			Additive Composition of Classes			Duality Principle			
			Stage			Stage				Stage			Stage			Stage			
			I	II	III	0	I	II	III	I	II	III	I	II	III	0	I	II	III
Control	< 9:6	10	–	–	10	–	2	2	6	–	2	8	1	1	8	4	6	–	–
	> 9:6	10	–	–	10	–	–	–	10	–	–	10	–	–	10	–	1	1	8
Reading Disability	< 9:6	10	–	–	10	–	2	7	1	3	3	4	1	1	8	4	6	–	–
	> 9:6	10	–	–	10	–	–	6	4	–	2	8	–	1	9	2	6	2	–
Arithmetic Disability	< 9:6	8	–	–	8	–	5	3	–	1	3	4	4	1	3	8	–	–	–
	> 9:6	11	–	–	11	–	2	7	2	–	6	5	–	1	10	4	7	–	–
Behavior Problems	< 9:6	8	–	1	7	1	2	4	1	3	2	3	2	1	5	4	4	–	–
	< 9:6	9	1	–	8	–	–	7	2	–	3	6	1	–	8	1	8	–	–
Reading & Arithmetic Disability	< 9:6	9	–	–	9	–	–	8	1	1	4	4	3	3	3	5	4	–	–
	> 9:6	12	–	–	12	–	–	9	3	–	2	10	2	2	8	3	9	–	–
Reading & Arithmetic Disability & Behavior Problems	< 9:6	10	–	–	10	–	1	8	1	1	5	4	3	1	6	7	2	1	–
	> 9:6	10	–	–	10	–	1	3	6	–	5	5	2	–	8	3	6	1	–

TABLE 4

PERFORMANCE OF CHILDREN BY STAGE OF DEVELOPMENT IN THE SPATIAL TASKS

			Concepts of Left and Right					Localization of Topographical Positions					Coordination of Perspectives					
			Stage					Stage					Stage					
Group	C.A. Level	N	IA	IB	II	IIIA	IIIB	I	IIA	IIB	IIIA	IIIB	O	IA	IB	IIA	IIB	III
Control	< 9:6	10		3	3	–	4	–	–	–	8	2	–	–	–	5	3	2
	> 9:6	10	–	–	1	2	7	–	–	–	1	9	–	–	–	–	1	9
Reading Disability	< 9:6	10	4	3	2	–	1	–	3	3	4	–	–	1	4	3	2	–
	> 9:6	10	–	–	5	1	4	–	1	–	2	7	–	–	–	1	3	6
Arithmetic Disability	< 9:6	8	–	4	4	–	–	–	2	1	5	–	1	1	4	2	–	–
	> 9:6	11	–	2	5	1	3	–	2	–	6	3	–	–	1	4	4	2
Behavior Problems	< 9:6	8	3	1	3	–	1	–	1	3	3	1	1	2	1	1	1	2
	> 9:6	9	–	1	4	–	4	–	1	1	1	6	–	–	3	–	1	5
Reading & Arithmetic Disability	< 9:6	9	1	6	2	–	–	–	5	1	3	–	–	2	3	2	1	1
	> 9:6	12	–	3	7	–	2	–	3	–	4	5	–	2	4	2	2	2
Reading & Arithmetic Disability & Behavior Problems	< 9:6	10	2	4	4	–	–	–	3	2	4	1	1	5	2	1	1	–
	> 9:6	10	1	1	5	–	3	–	–	1	4	5	–	2	–	3	3	2

Performance on the Piagetian Tasks.

Conservation of Number.

The Conservation of Number task was designed to test the child's understanding that number remains constant regardless of the configuration of the elements in the group. Stages I and II refer to the preoperational period when the child believes that the number will change when the elements are rearranged. At Stage III the child accepts that number is conserved no matter how the elements are arranged.

It is very clear from the data that the majority of children, both control and learning disabled, at each level, had acquired the understanding of conservation of number. Only two of 117 children were non-conservers. The two non-conservers were categorized as behavior problems.

The percent of children (rounded to the nearest whole number) who were clearly operational on each task is presented in Table 5. The descriptive graphs are presented in figures 1 through 16. Almost 100 percent of the children in each category at each age level were operational on Conservation of Number (see Table 5 and Figures 1 and 9).

Seriation.

The Seriation task required the child to arrange two series of pictures, each drawn to a different scale, from smallest to largest and to relate the two series according to their ordinal position. Stage I children should be able to perform this part of

TABLE 5

PERCENTAGES OF CHILDREN WHO WERE CLEARLY OPERATIONAL ON THE LOGICO-MATHEMATICAL AND SPATIAL DEVELOPMENT TASKS

Group	C.A. Level	N	Number Conservation	Seriation	Multiplication of Classes	Additive Composition of Classes	Duality Principle C.O.	Duality Principle F.O.	Concepts of Left and Right	Topographical Positions	Coordination of Perspectives
Control	< 9:6	10	100	60	80	80	0	0	40	100	20
	> 9:6	10	100	100	100	100	90	80	90	100	90
Reading Disability	< 9:6	10	100	10	40	80	0	0	10	40	0
	> 9:6	10	100	40	80	90	20	0	50	90	60
Arithmetic Disability	< 9:6	8	100	0	50	38	0	0	0	63	0
	> 9:6	11	100	18	45	91	0	0	36	82	18
Behavior Problems	< 9:6	8	88	13	38	62	0	0	13	50	25
	> 9:6	9	89	22	67	89	0	0	44	78	56
Reading & Arithmetic Disability	< 9:6	9	100	11	44	33	0	0	0	34	11
	> 9:6	12	100	25	83	67	0	0	17	75	16
Reading & Arithmetic Disability & Behavior Problems	< 9:6	10	100	10	40	60	10	0	0	50	0
	> 9:6	10	100	60	50	80	10	0	30	90	20

PERCENTAGES OF CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS CLEARLY OPERATIONAL ON PIAGETIAN TASKS

FIGURE 1

CONSERVATION OF NUMBER

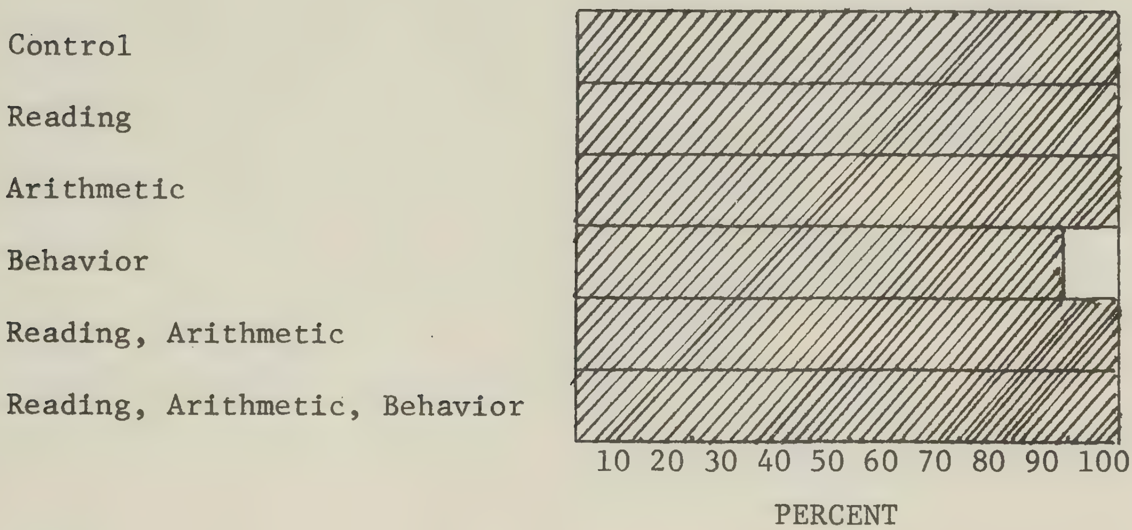
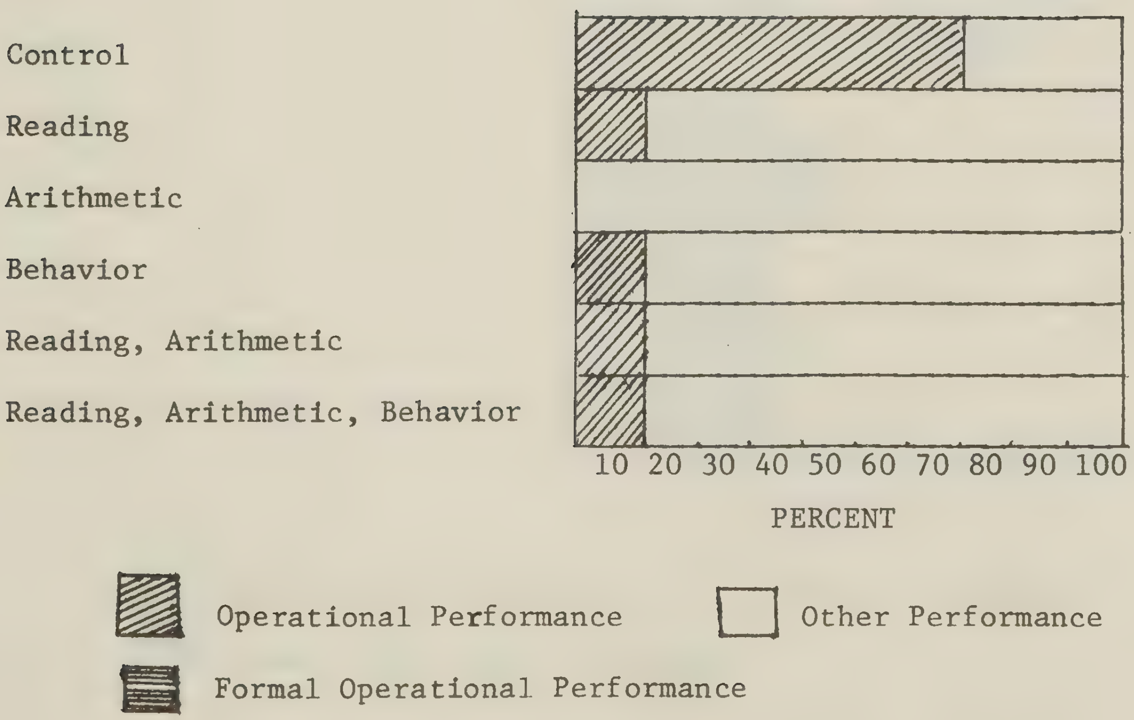


FIGURE 2

SERIATION



PERCENTAGES OF CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS CLEARLY OPERATIONAL ON PIAGETIAN TASKS

FIGURE 3

ADDITIVE COMPOSITION

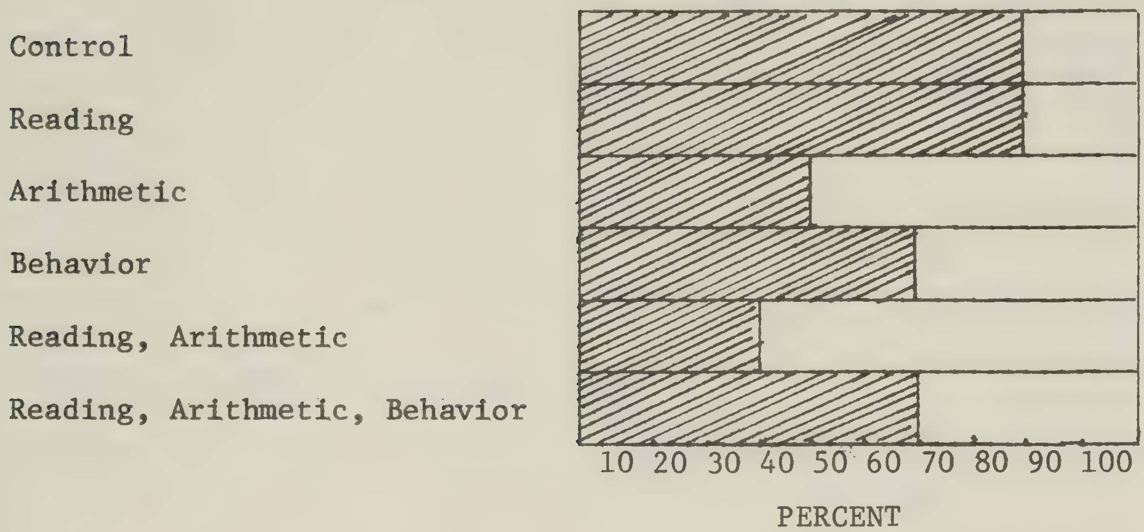
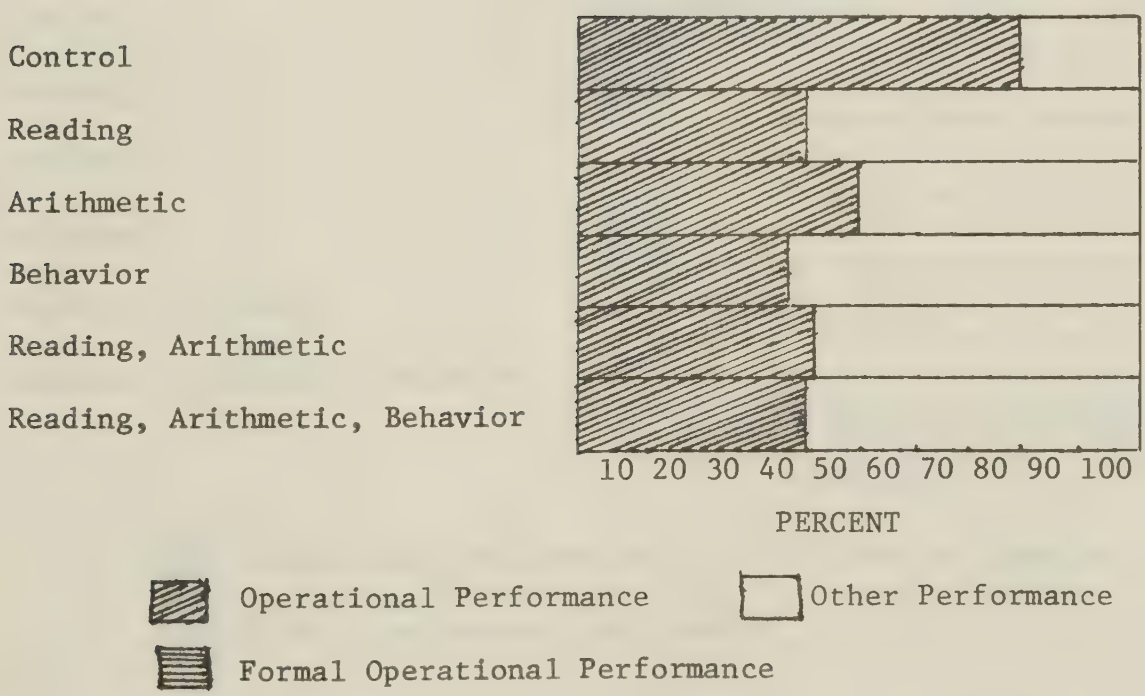


FIGURE 4

MULTIPLICATIVE CLASSIFICATION



PERCENTAGES OF CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS CLEARLY OPERATIONAL ON PIAGETIAN TASKS

FIGURE 5

DUALITY PRINCIPLE

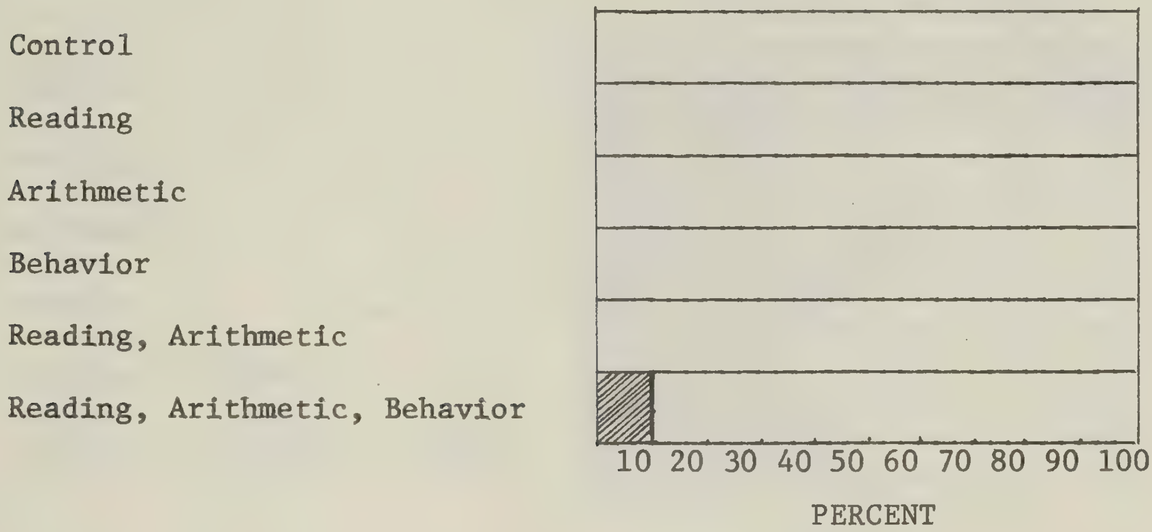
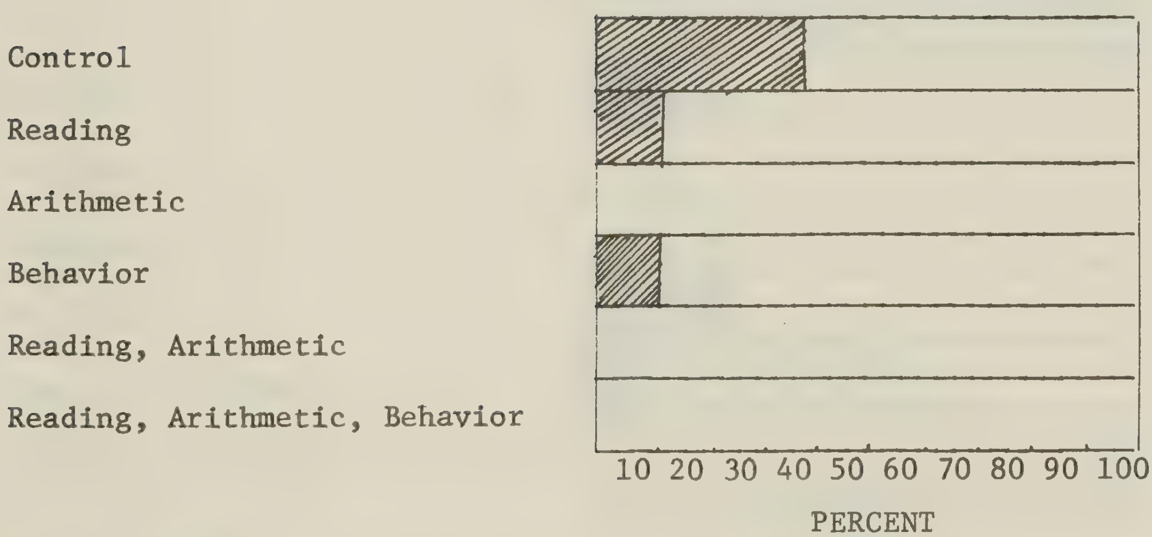


FIGURE 6

CONCEPTS OF LEFT AND RIGHT



Operational Performance

Other Performance

Formal Operational Performance

PERCENTAGES OF CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS CLEARLY OPERATIONAL ON PIAGETIAN TASKS

FIGURE 7

TOPOLOGICAL POSITIONS

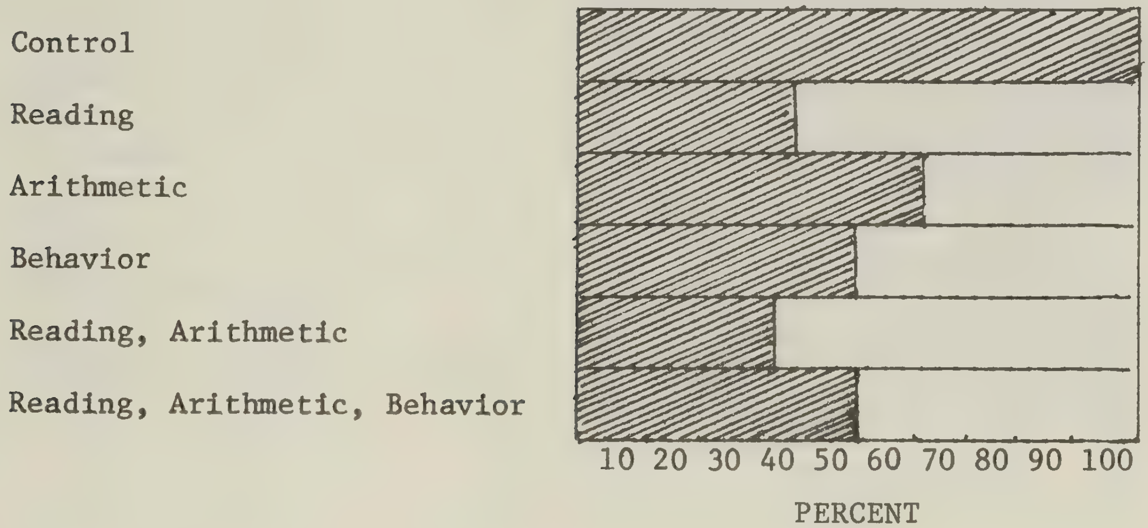
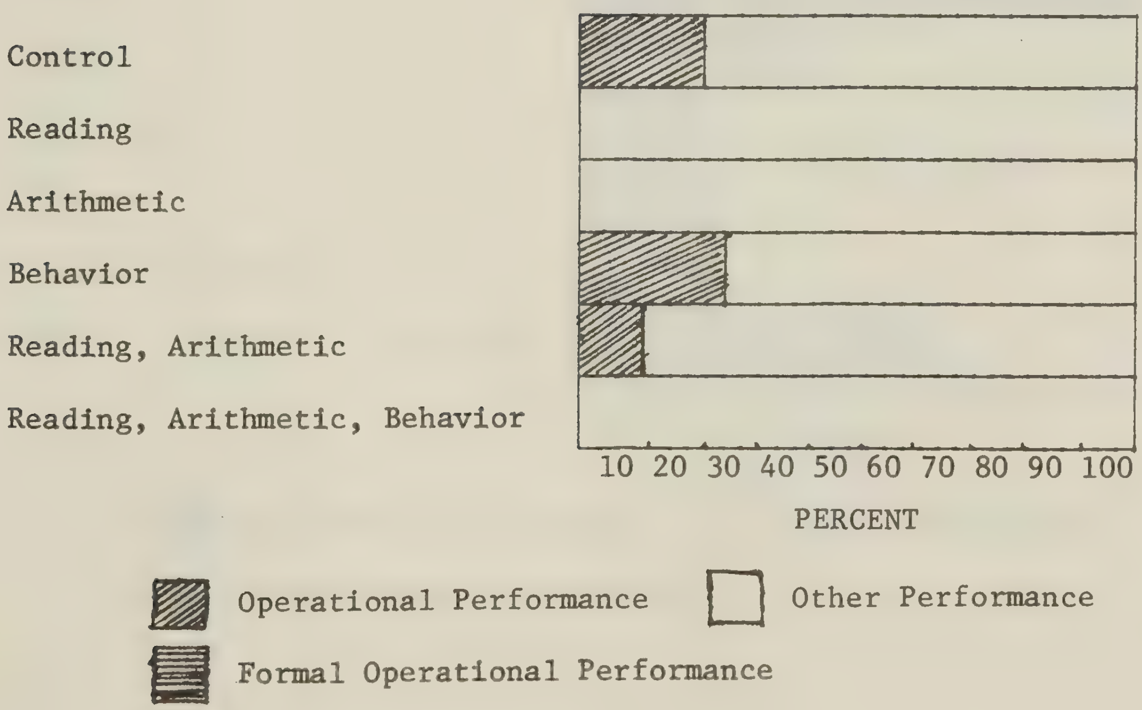


FIGURE 8

COORDINATION OF PERSPECTIVES



PERCENTAGES OF CHILDREN OLDER THAN NINE YEARS SIX MONTHS CLEARLY OPERATIONAL ON PIAGETIAN TASKS

FIGURE 9

CONSERVATION OF NUMBER

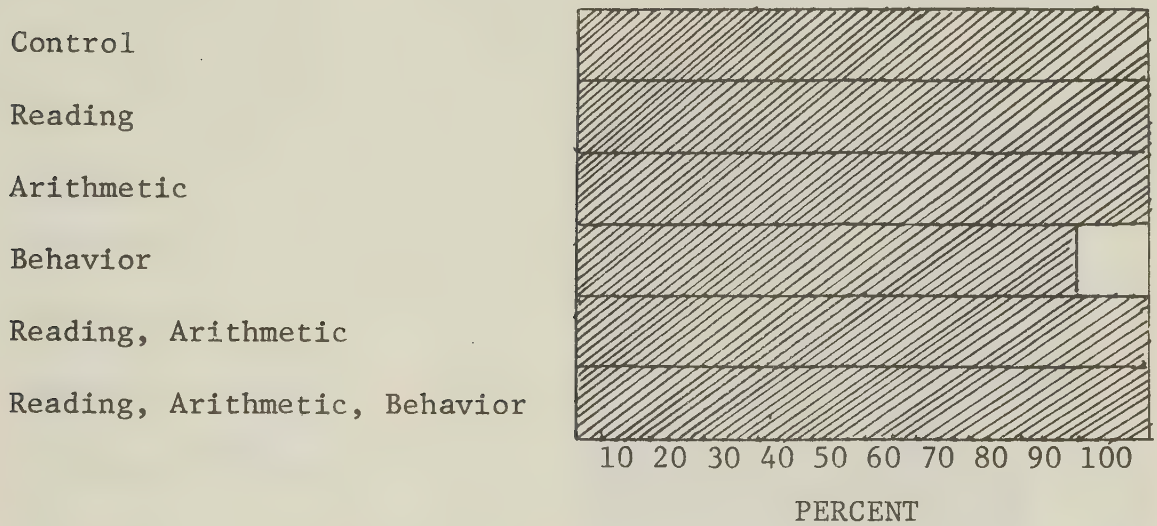
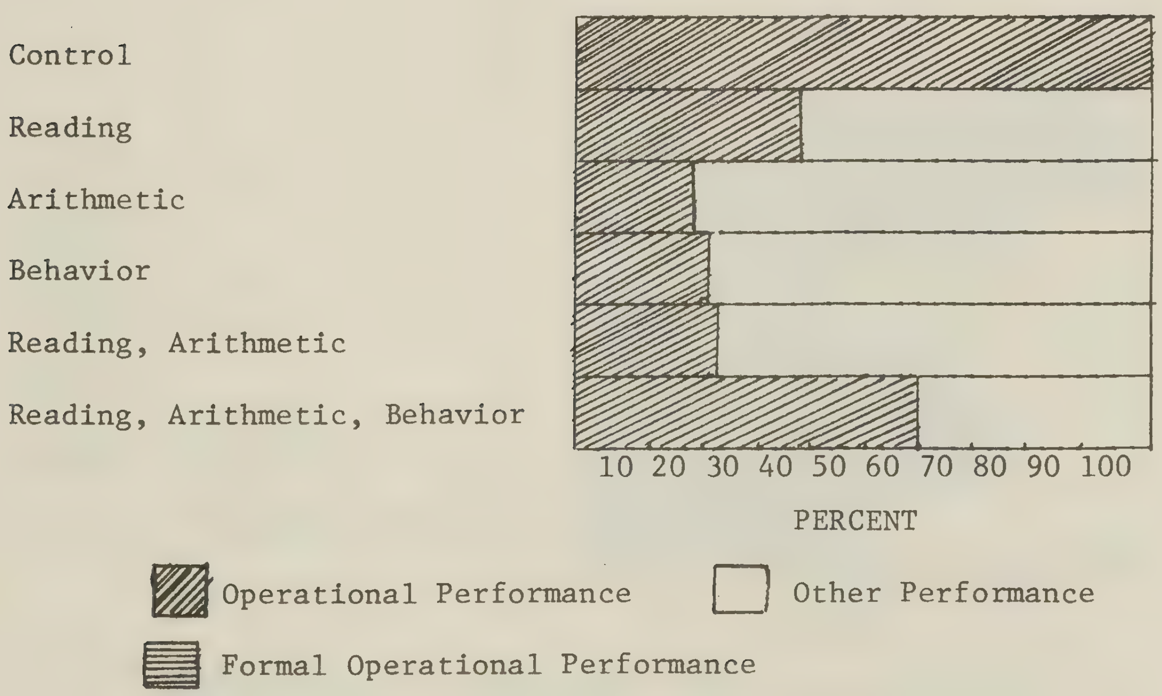


FIGURE 10

SERIATION



PERCENTAGES OF CHILDREN OLDER THAN NINE YEARS SIX MONTHS CLEARLY OPERATIONAL ON PIAGETIAN TASKS

FIGURE 11

ADDITIVE COMPOSITION

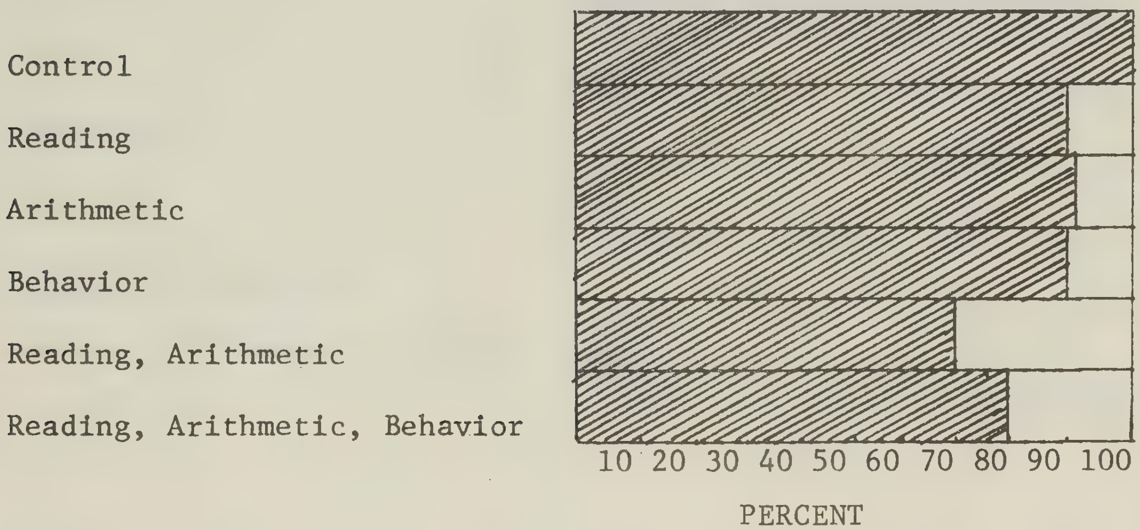
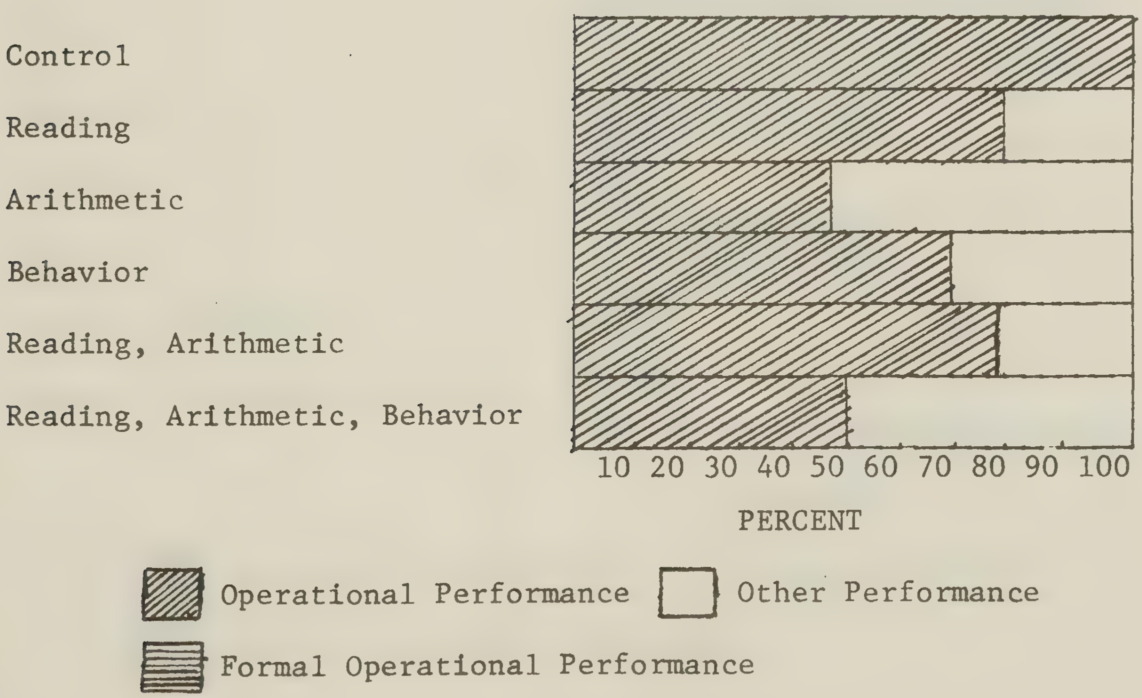


FIGURE 12

MULTIPLICATIVE CLASSIFICATION



PERCENTAGES OF CHILDREN OLDER THAN NINE YEARS SIX MONTHS CLEARLY OPERATIONAL ON PIAGETIAN TASKS

FIGURE 13

DUALITY PRINCIPLE

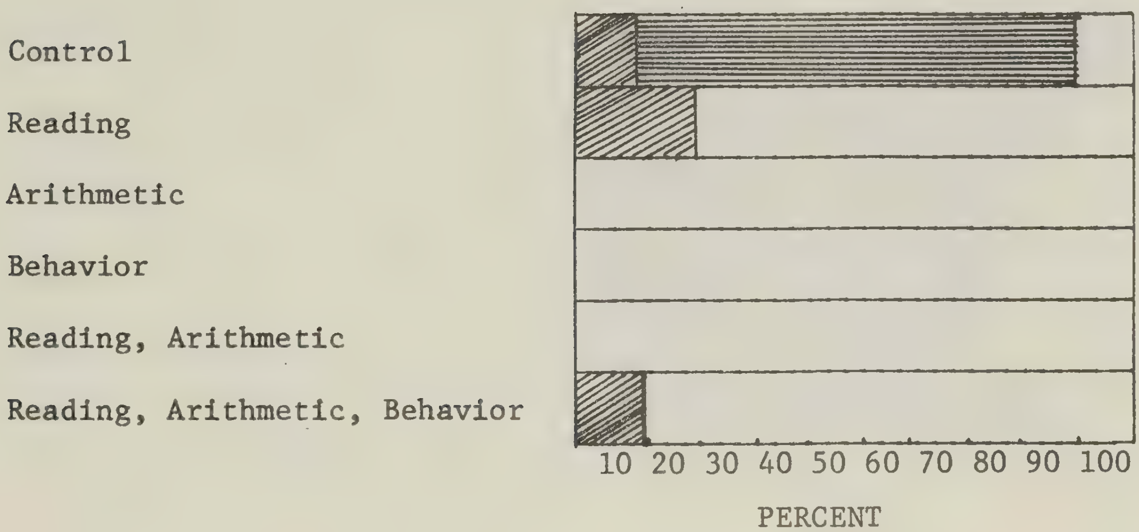
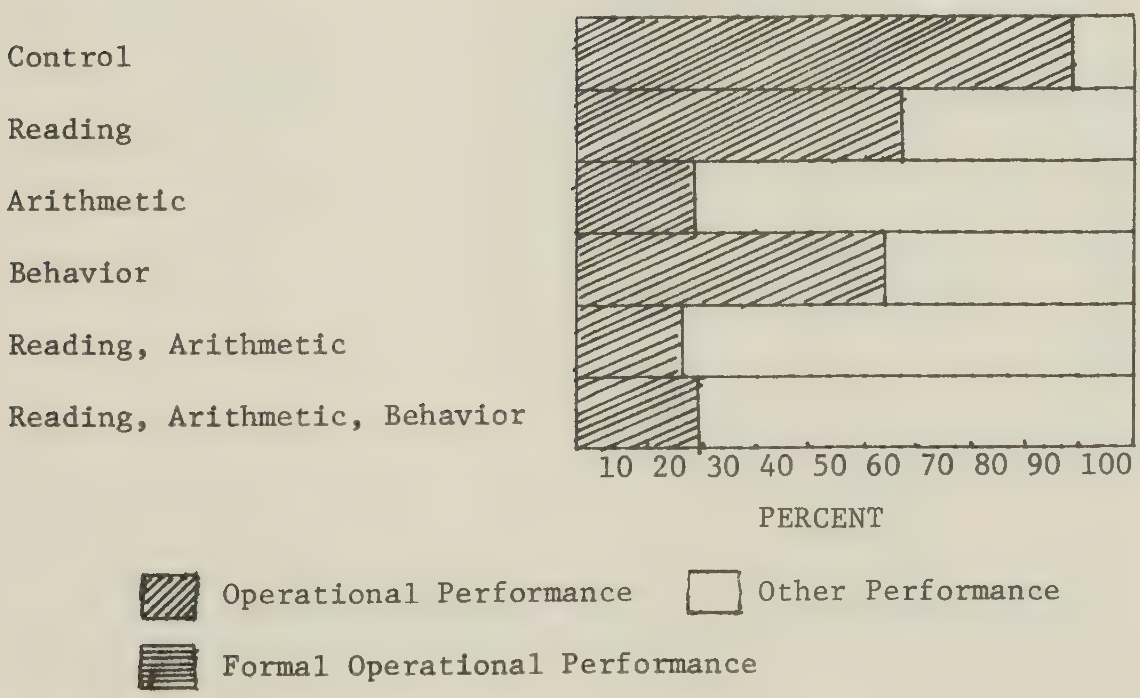


FIGURE 14

CONCEPTS OF LEFT AND RIGHT



PERCENTAGES OF CHILDREN OLDER THAN NINE YEARS SIX MONTHS CLEARLY OPERATIONAL ON PIAGETIAN TASKS

FIGURE 15

TOPOLOGICAL POSITIONS

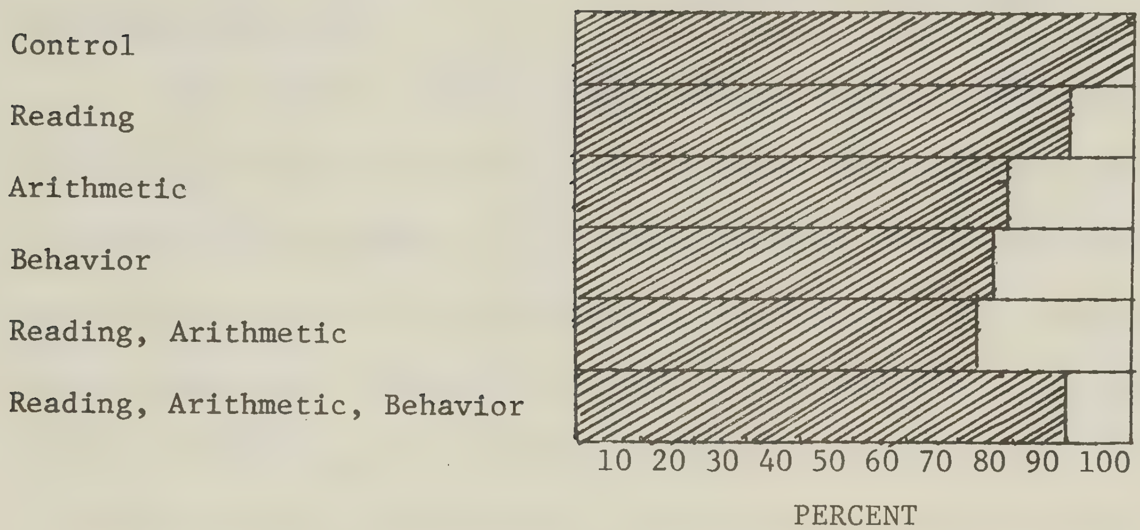
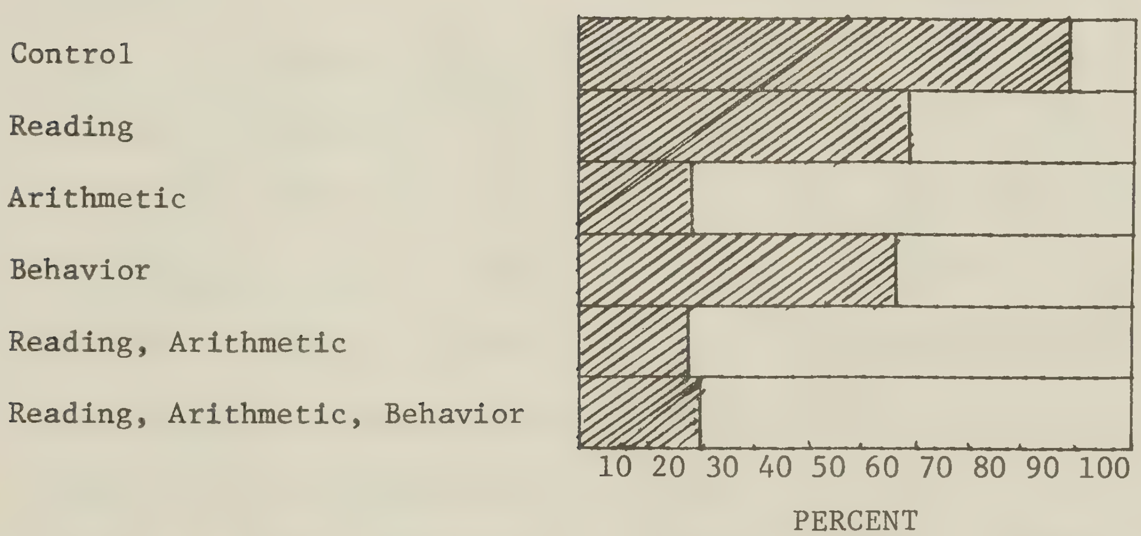
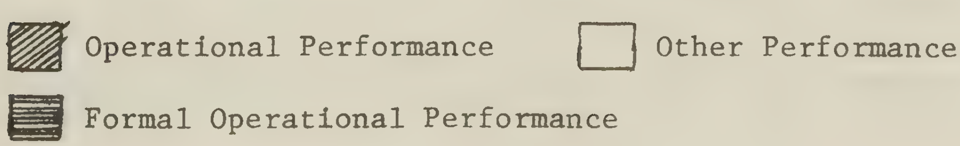


FIGURE 16

COORDINATION OF PERSPECTIVES





the task. Stage II children should be able to match the two series when the elements are parallel even though they are not in one-to-one correspondence by combining cardination and ordination systems. Only at Stage III can the child reorder the two series when they are no longer parallel.

Sixty percent of the younger control subjects and 100 percent of the older control subjects were at Stage III compared to 10 percent and 40 percent of the reading disabled children in the younger age category and older age category respectively. The percentages for the arithmetic disabled children were 0 and 18 percent; for the children with behavior problems 13 and 22 percent; for the children with both reading and arithmetic disabilities 11 and 25 percent and for the children with three disabilities (reading, arithmetic and behavior), the percentages were 10 and 60 (see Table 5 and Figures 2 and 10).

It is obvious that seriation ability is an important ability for the attainment of reading and arithmetic skills at the younger age level. Sixty percent of the controls were operational compared to only 10, 0, 13, 11, and 10 percent for the children categorized as having academic or behavior deficits. One hundred percent of the older control subjects were operational on this task compared to 40 percent of the reading disabled, 18 percent of the arithmetic disabled, 22 percent of the children with behavior problems, 25 percent of the children with deficits in both academic areas and 60 percent of the

children with deficits in all three areas. It would seem that seriation is a pre-requisite skill for both arithmetic and reading achievement and is related to the development of adequate behavior. It appears to be more closely related to an arithmetic disability or a behavior problem or to a combination of reading and arithmetic disabilities than to reading disability alone particularly at the older age level. The stage of development for the reading disabled children and for children with all three disabilities increased somewhat more from the younger level to the older level than for the other disability groups. The difference in percent from less than nine years six months to more than nine years six months was very slight for the arithmetic, behavior and reading and arithmetic disability groups. It is difficult to explain the large difference in percentages between the two age groups for the children with three deficit areas.

Additive Composition of Classes.

This test requires the child to recognize a subclass as an integral part of the larger whole class. At Stage I the child cannot think simultaneously of the whole class B and the parts A and A^1. The child at Stage II gradually realizes that the class B contains more elements than either A or A^1. This is an intuitive discovery, however, and he does not assume this fact because of the inclusions resulting from additive composition. At Stage III, the concrete operational stage, the child immediately grasps that class B is larger

than either class A or A^1 and can explain his answer in terms of additive composition.

Eighty percent of the younger control children and 100 percent of the older control children were operational on this task. The percentages of children operational at the younger and older age levels in the dysfunction groups were as follows: reading 80 and 90 percent, arithmetic 38 and 91 percent, behavior 63 and 89 percent, reading and arithmetic 33 and 67 percent and reading, arithmetic and behavior 60 and 80 percent (see Table 5 and Figures 3 and 11).

At the younger age level 80 percent of the control children were operational compared to 80, 38, 63, 33 and 60 percent in the dysfunction groups. It appears that the arithmetic disability group and the combined arithmetic and reading disability group are most similar. Almost all of the older children were operational on the additive composition of classes task. The percentages were 100 percent for the controls and 90, 91, 89, 67 and 80 percent for the five dysfunction groups. At this age level it was the combined reading and arithmetic disability group which experienced the most difficulty with the task.

Multiplication of Classes.

This task was designed to investigate the ability of the child to recognize that two classes may overlap with respect to their membership. The Stage I child cannot sort a collection of red and blue circles and squares into four basic groups. The material is used to form graphic collections. The Stage II child will usually sort the material into two groups, the criterion for grouping is either color or shape. At Stage III, the concrete operational stage, the child sorts the material on the basis of both criteria, color and shape. The child can immediately cross-classify and recognize that two classes may overlap with respect to membership.

Eighty percent of the younger control children and 100 percent of the older control children were operational on the task. The percentages for reading disabled children in the younger and older age categories were 40 and 80 percent respectively, for the arithmetic disabled children 50 and 45 percent, for the behavior disabled children 38 and 67 percent, for children with both reading and arithmetic disabilities 44 and 83 percent and for the children with combined reading, arithmetic and behavior problems the percentages were 40 and 50 (see Table 5 and Figures 4 and 12).

At the younger age level 80 percent of the control children were operational compared to 40, 50, 38, 44 and 40 percent of children in the five dysfunction groups. The percent of children who were operational for all the disability groups is quite similar.

One hundred percent of the control children at the older age level were operational compared to 80, 45, 67, 83 and 50 percent of the children in the disability groups. Many of the older children were operational on this task. The lowest percentages were found in the arithmetic (45 percent) and in the combined reading, arithmetic and behavior (50 percent) disability groups. One might hypothesize that whatever is causing the arithmetic disability might be a significant factor in the problems experienced by the children with the combined reading, arithmetic and behavior difficulties.

The Duality Principle.

Success with this task depends upon the ability of the child to relate subclass to class when there are multiple classes. The child must also be capable of dealing with a hierarchy of classes, for example, ducks $<$ birds $<$ animals. In addition, the child must also be able to handle the negation of classes and subclasses. At Stage I the child is capable of spontaneous classification. The child at Stage II can sort into subclasses. At Stage III, the concrete operational stage, the child can handle the inclusion relation but not the negation of classes and subclasses. This test includes a formal operational stage, Stage IV, and at this level the child can adequately deal with all aspects of the task.

At the younger age level, with one exception, no children were functioning at the concrete operational or formal operational stages of this test. The exception was one child in the behavior disability group (see Table 5 and Figure 5). At the older age level 90 percent of the control children were at the concrete operational stage and 80 percent of this group were at the formal operational stage. Twenty percent of the reading disabled children and ten percent of the children in the combined reading, arithmetic and behavior disability group had reached Stage III, concrete operations. None of the other children at this age level were operational on the task (see Table 5 and Figure 13). It appears that the older control children were able to advance in logical thinking skills (90 percent concrete operational and 80 percent formal operational) but no disabled child could accomplish this.

Concepts of left and right.

This task investigates some of the elementary concepts of projective space. During Stage I the child can only designate the parts of his own body in terms of left and right. At Stage II the child can correctly designate left and right on the body of a person facing opposite. At Stage III the child can consider the concepts of left and right as relative and from the point of view of things themselves. The relationships of left and right among three objects placed in front of the child are understood. This is the stage of concrete operations.

Forty percent of the younger control children and 90 percent of the older control children were operational on this task. The percentages of children operational at the younger and older age levels respectively in the dysfunction groups were as follows: reading 10 and 50; arithmetic 0 and 36; behavior 13 and 44; reading and arithmetic 0 and 17 and reading, arithmetic and behavior 0 and 30 percent (see Table 5 and Figures 6 and 14).

At the younger age level 40 percent of the control children were operational compared to 10, 0, 13, 0 and 0 percent in the disability groups. The majority of the younger children had not reached the stage of concrete operations. Piaget (1928) suggested that children often did not become operational on this task until the age of eleven or twelve years and this was substantiated by Laurendeau and Pinard (1970). No doubt this accounts for the small number of the younger children who were operational on this task. At the older age level 90 percent of the control children were operational compared to 50, 30, 44, 17 and 30 percent in the disability groups. The lowest percentages were found in the arithmetic (36 percent); reading and arithmetic (17 percent) and the reading, arithmetic and behavior (30 percent) disability groups. The similarity of the three groups containing arithmetic disabled children should be noted.

Localization of Topographical Positions.

This test was designed to investigate the development of projective spatial relationships in children. At Stage I the child succeeds only with problems that require topological solutions. At Stage II the child solves problems that involve the projective relations of left-right and before-behind. Performance, however, is limited by the egocentrism of the child. At Stage III the child is capable of the operational coordination of projective relations. The problems at this stage deal with the relationships of left-right and before-behind when one of two identical landscape boards has been rotated. The child is capable of the necessary coordinations and reversals required for success.

All of the younger control children and all of the older control children were operational on this task. The percentages of children operational at the younger and older age levels respectively in the dysfunction groups were as follows: reading 40 and 90; arithmetic 63 and 82, behavior 50 and 78, reading and arithmetic 34 and 75 and reading, arithmetic and behavior 50 and 90 percent (see Table 5 and Figures 7 and 15).

At the younger age level 100 percent of the control children were operational compared to 40, 63, 50, 34 and 50 percent in the dysfunction groups. The lowest percentages were in the reading (40 percent) and reading and arithmetic (34 percent) disability groups.

At the older age level 100 percent of the control children were operational on the task compared to 90, 82, 78, 75 and 90 percent in the disability groups. The majority of older disabled children are operational. They seem to have outgrown the problems experienced on this task by the younger disabled children.

Coordination of Perspectives.

Piaget (1928) designed his classic "three mountains" experiment to investigate the ability of the child to adopt different viewpoints. The Coordination of Perspectives is an advanced concept of projective space. At Stage I the child is completely egocentric and unable to consider any viewpoint other than his own. At Stage II partial decentration occurs. The child seems to be aware of perspectives other than his own, however, he often cannot justify the non-egocentric responses he makes. Stage III is one of operational coordination. The child no longer makes egocentric errors. He is aware of the perspectives of others and can justify the choices he makes.

Twenty percent of the younger control children and 90 percent of the older control children were operational on this task. The percentages of children operational at the younger and older age levels respectively in the dysfunction groups were as follows: reading 0 and 60; arithmetic 0 and 18; behavior 25 and 56; reading and arithmetic 11 and 16 and reading, arithmetic and behavior 0 and 20 percent (see Table 5 and Figures 8 and 16). At the younger age

level 20 percent of the control children were operational compared to 0, 0, 25, 11 and 0 percent in the disability groups. The majority of children at this age level were preoperational on the task and there was little difference between the groups. At the older age level, however, 90 percent of the control children were operational on the "perspectives" task compared to 60, 18, 56, 16 and 20 percent in the dysfunction groups. Lowest percentages were found in the arithmetic (18 percent), reading and arithmetic (16 percent) and reading, arithmetic and behavior (20 percent) disability groups. In each case arithmetic disabled children are involved.

Statistical Analysis.

A one-way analysis of variance (ANOVA) was computed to determine whether significant differences existed between the group means at both age levels for the following eight variables: Conservation of Number, Seriation, Additive Composition, Multiplicative Classification, Duality Principle, Concepts of Left and Right, Topographical Positions and Coordination of Perspectives (Table 6). A Scheffé multiple comparison of means was carried out for each variable at both age levels to determine between which groups the differences were significant (Tables 7 and 8).

TABLE 6

RESULTS OF ONE WAY ANALYSIS OF VARIANCE FOR EIGHT VARIABLES FOR SUBJECTS AT TWO AGE LEVELS

Variable	Younger than 9:6				Older than 9:6			
	MS	df	F	P	MS	df	F	P
Conservation of Number[1]								
Seriation	4.62 1.63	5 49	2.84	0.0250*	4.80 1.05	5 56	4.575	< .01
Additive Composition	4.31 2.86	5 49	1.51	0.2052	1.66 1.34	5 56	1.24	> .05
Multiplicative Classification	2.91 2.16	5 49	1.35	0.2613	1.82 .75	5 56	2.43	< .05
Duality Principle	0.32 1.28	4 42	0.25	0.9067	15.58 1.10	5 46	14.17	0.0000*
Concepts of Left and Right	4.65 2.23	5 49	2.09	0.0829	4.28 1.68	5 56	2.55	0.0380*
Topographical Positions	2.19 0.78	5 49	2.82	0.0256*	1.51 0.92	5 56	1.64	0.1649
Coordination of Perspectives	6.35 1.99	5 49	3.19	0.0142*	11.60 2.16	5 56	5.37	0.0004*

*differences significant at .05 level or less

[1]values not computed since all groups except two had zero variance

TABLE 7

SIGNIFICANT RESULTS OBTAINED FROM SCHEFFÉ MULTIPLE COMPARISON OF MEANS FOR SUBJECTS YOUNGER THAN NINE YEARS SIX MONTHS

Variable	Groups Compared	P
Seriation	Control and Arithmetic	.0595
Topographical Positions	Control and Reading and Arithmetic	.0451
Coordination of Perspectives	Control and Reading, Arithmetic and Behavior	.0332

TABLE 8

SIGNIFICANT RESULTS OBTAINED FROM SCHEFFÉ MULTIPLE COMPARISON OF MEANS FOR SUBJECTS OLDER THAN NINE YEARS SIX MONTHS

Variable	Groups Compared	p
Seriation	Control and Arithmetic	$< .01$
	Control and Behavior	$< .10$
	Control and Reading and Arithmetic	$< .10$
Duality Principle	Control and Reading	.0001
	Control and Arithmetic	.0000
	Control and Behavior	.0000
	Control and Reading and Arithmetic	.0000
	Control and Reading, Arithmetic and Behavior	.0000
Concepts of Left and Right	Control and Reading and Arithmetic	.0887
Coordination of Perspectives	Control and Reading and Arithmetic	.0038
	Control and Reading, Arithmetic and Behavior	.0445
	Reading and Reading and Arithmetic	.0639
	Control and Arithmetic	.1078

It should be mentioned that the ANOVA revealed significant differences between the group age means at the less than nine years six months age level ($F = 3.47$, $p = .0092$). The Scheffé test indicated that significant differences ($p = .0958$) existed between the age means for the behavior disability group and the combined reading, arithmetic and behavior disability group. Scheffé has recommended that due to the rigorous nature of his test differences $< .10$ should be considered significant (Winer, 1962). There was no significant differences between the age means at the greater than nine years six months age level.

No significant differences between the groups at either age level were found on the Conservation of Number task. Significant differences were found at both age levels for the Seriation task (younger age level, $F = 2.84$, $p = .00595$; older age level, $F = 4.575$, $p = < .01$). The Scheffé test indicated significant differences between the control group and:

1. the arithmetic disability group at the younger age level ($p = .0595$).
2. the arithmetic disability group at the older age level ($p < .01$).
3. the behavior disability group at the older age level ($p < .10$).
4. the reading and arithmetic group at the older level ($p < .10$).

The ANOVA did not reveal any significant differences between the group means at either age level for Additive Composition of Classes. Significant differences were indicated by the ANOVA at the older age level for Multiplicative Classification ($p < .05$). The Scheffé test, however, did not detect significant differences between the group means for the multiplicative classification test at a probability level $< .10$. The ANOVA revealed significant differences for the Duality Principle at the older age level ($F = 14.17$, $p = .0000$). The Scheffé test indicated significant differences between the control and:

1. the reading disability group ($p = .001$).
2. the arithmetic disability group ($p = .0000$).
3. the behavior disability group ($p = .0000$).
4. the reading and arithmetic disability group ($p = .0000$).
5. the reading, arithmetic and behavior disability group ($p = .0000$)

The ANOVA revealed significant differences between the group means for the younger children on two spatial tasks: the Localization of Topographical Positions ($F = 2.82$, $p = .0256$) and Coordination of Perspectives ($F = 3.19$, $p = .0142$). For the Localization of Topographical Positions the Scheffé test detected significant differences between the control and the combined reading, arithmetic and behavior disability group ($p = .0958$). The Scheffé test also detected

significant differences on the Coordination of Perspectives test between the control and the combined reading, arithmetic and behavior disability group (p = .0332).

At the older age level the ANOVA detected significant differences between the group means on two spatial tasks: the Concepts of Left and Right (F = 2.55, p = .0380), and the Coordination of Perspectives (F = 5.37 p = .004). The Scheffé test detected significant differences between the control group and the reading and arithmetic disability group (p = .0887) on the Concepts of Left and Right test. For the Coordination of Perspectives task, significant differences were detected by the Scheffé test between:

1. the control and reading and arithmetic disability group (p = .0038).
2. the control and the reading, arithmetic and behavior disability group (p = .0445).
3. the control and the arithmetic disability group (p = .1078).
4. the reading disability and the reading and arithmetic disability group (p = .0639).

CHAPTER V

CONCLUSIONS

This study was designed to investigate specific questions regarding the performance on various Piagetian tasks by groups of children characterized by different types and combinations of learning disabilities. One hundred and seventeen children were involved in the investigation. Twenty of the children served as normal controls and 97 of the children were learning disabled. The learning disabled children were identified as belonging to five different dysfunction groups: (1) reading disability, (2) arithmetic disability, (3) behavior disability, (4) reading and arithmetic disability and (5) reading, arithmetic and behavior disability. A control group and five dysfunction groups were identified at two age levels, one younger than nine years six months, one older than nine years six months. A battery of Piagetian tasks including tests for mathematical, classification and spatial concepts was individually administered to each child. In general, the analysis of the data presented in the preceding chapter indicated that:

1. The developmental stages described by Piaget for the tasks used in this study were observed in the learning disabled children.
2. In some cases, there was a departure from the hypothesized sequence of development postulated by Piaget for the tasks.

3. Some significant differences existed between the performance of the control and dysfunction groups on some of the tasks.

4. A number of older children were operational on the Piagetian tasks but continued to experience learning difficulties.

The questions proposed for investigation will now be considered.

QUESTION 1: Will the developmental stages described by Piaget for normal children on the various tests of mathematical concepts, classification and spatial development be observed in learning disabled children?

The results indicated that the children in the dysfunction groups did manifest the developmental stages described by Piaget for the tasks included in this study. The performance of the learning disabled children at the various stages did not differ from that of the control groups at either age level.

QUESTION 2: Will the sequence of development proposed by Piaget for mathematical concepts, classification and spatial development be observed in the learning disabled children?

The majority of learning disabled children did follow the developmental sequence described by Piaget. Departures from this hypothesized sequence, however, occurred at both age levels in the

tests for the Duality Principle, the Localization of Topographical Positions and the Concepts of Left and Right. These results are summarized in Table 9. Laurendeau and Pinard (1970) mentioned that a number of subjects in their study had demonstrated irregular developmental sequences on Piagetian spatial tasks. However, the protocols for these subjects were omitted from the final analytical report since Laurendeau and Pinard attributed the performance to accidental factors. Since 29 cases of altered developmental sequence were observed in the present study the writer is unwilling to consider the occurrences accidental. The tests in which these differences were noted will be discussed individually.

The Duality Principle.

Three children at the younger age level, one in the control group and two in the reading disability group, demonstrated an altered sequence. At the older age level one child in the behavior disability group and one in the arithmetic disability group exhibited the same problem. In all cases the children answered the Stage IV questions which demonstrate an understanding of the duality principle which exists between the ordering of classes and the ordering of their complements as expressed by $(A) < (B) \longrightarrow (\text{not } A) > (\text{not } B)$. These same children, however, did not supply adequate answers for the Stage III general inclusion questions which indicate an understanding that the class of animals (B) includes the class of birds (A) which includes the subclass of ducks (A^1) as expressed by $(A^1) < (A) < (B)$.

TABLE 9

NUMBERS OF SUBJECTS IN VARIOUS DYSFUNCTION GROUPS AT TWO AGE LEVELS WHO DEPARTED FROM EXPECTED DEVELOPMENTAL SEQUENCE ON TESTS OF DUALITY PRINCIPLE, LOCALIZATION OF TOPOLOGICAL POSITIONS AND CONCEPTS OF LEFT AND RIGHT

Group	Chronological Age Level (years and months)	Duality Principle	Topographical Positions	Concepts of Left and Right	N
Control	< 9:6	1		1	2
	> 9:6				
Reading Disability	< 9:6	2	3	2	7
	> 9:6		1	1	2
Arithmetic Disability	< 9:6		2	1	3
	> 9:6	1		1	2
Behavior Problems	< 9:6		1		1
	> 9:6	1	1	1	3
Reading and Arithmetic Disability	< 9:6		3		3
	> 9:6		3	1	4
Reading and Arithmetic Disability and Behavior Problems	< 9:6			1	1
	> 9:6			1	1
N		5	14	10	29

The verbal replies of these children did not differ from the replies of children who followed the postulated sequence. In the writer's opinion the children may have been distracted by the test materials. When answering the inclusion questions the attention of the child was focused on the pictures of ducks, other birds and farm animals. When answering the duality questions the child did not concentrate so much on the pictures but tended to be more contemplative. This thoughtful attitude may have provoked the success with the duality questions.

Localization of Topographical Positions.

Nine of the younger children, three in the reading disability group, two in the arithmetic disability group, one in the behavior disability group and three in the combined reading and arithmetic disability group did not follow the expected pattern of development for the Localization of Topographical Positions task. At the older age level, five children, one in the reading disability group, one in the behavior disability group and three in the combined reading and arithmetic disability group also departed from the developmental pattern postulated by Piaget. In all fourteen cases the children had reached stages IIA and IIIA but not IIB. Since Laurendeau and Pinard (1970) had reported a number of instances in which subjects tested by them had performed in a similar manner, the examiner in this study was alert to the possibility of such an occurrence. The children achieved the required proportion of the seven easiest problems involving left-right relationships before (Stage IIA) and after

(Stage IIIA) rotation of a small landscape board. At Stage IIB, however, they failed the five most difficult problems involving the coordination of the projective relationships of before-behind and left-right even when the landscape was not rotated. At both substages IIA and IIIA of this test topographical cues (e.g., neighborhood, enclosure, surrounding etc.) are extremely helpful in enabling the child to properly position his "man" on the landscape. Laurendeau and Pinard (1970) stated that the child performs on an egocentric level at substages IIA and IIB with a reduction of egocentricity beginning at IIB. A more general decentration occurs at substages IIIA and IIIB as the child demonstrates an increased ability to reverse the left-right, before-behind dimensions. The performance of these children on the other spatial development tasks merits attention at this point. Of the fourteen children discussed here, seven were completely egocentric on the Coordination of Perspectives task which is purported to be a more difficult test, six demonstrated partial decentration and one was operational on the task. Since half of the children were indicating signs of at least partial decentration on the "perspectives" test the writer suggests that the performance of these children on the Topographical Positions test may be attributed more to their strong dependence on topographical cues than to the degree of their egocentricity. Regarding the performance of these children on the Concepts of Left and Right task only one child was operational and half of them were only at Stage IB (subject understands the designation

of left and right on his own body). On the Concepts of Left and Right test the majority of children performed poorly, yet they seemed able to deal with these relationships on the Topographical Positions test. These results would also appear to support the argument for the strong influence of topographical cues on these children. Piaget (1928) postulated that the child first grasps spatial relationships that are topographical in nature. Perhaps these particular children are for some reason experiencing a developmental lag with respect to the projective and Euclidean spatial relationships.

Concepts of Left and Right.

Five children at the younger age level, one in the control group, two in the reading disability group, one in the arithmetic disability group and one in the combined reading arithmetic and behavior disability group presented a developmental sequence on the Concepts of Left and Right test that differed from the expected pattern. The same was true of five children at the older age level, one in each of the dysfunction groups. In two cases Stage II, the correct designation of left and right on the person standing opposite to the subject, preceded Stage IB, the correct designation of left and right on the subject's own body; in one case Stage IIIA, the recognition of the relative positions of three visible objects preceded Stage II; in three cases both Stages IIIA and IIIB, the recognition of the relative positions of three concealed objects, preceded Stage II; in one case Stage IIIB preceded both Stages II and IIIA and in three cases Stage IIIB

preceded Stage IIIA. In attempting to find an explanation for the rather erratic performance of these children their success with other spatial tasks was considered. Among the younger children, three were preoperational and two were operational on the Topographical Positions task; four were completely egocentric and one showed signs of partial decentration on the Coordination of Perspectives task. Among the older children, four were operational on the Topographical Positions task and one was preoperational. Two were operational and three indicated partial decentration on the "perspectives" task. Piaget (1928) linked the ability of the child to handle the concepts of left and right with the degree of egocentrism existing within the child. Among the five younger children perhaps the lack of decentration from their own viewpoint may in some way account for their uncertain performance. However, one might question whether this is true to the same extent with the older children. Their performance on the other spatial tasks seems to indicate a capacity to deal with cognitive space. Perhaps some other type of perceptual factor is involved here. Specifically, the child may have a developmental lag in one or more areas of what Piaget refers to as perceptual space which is directly affecting performance on this test of representational space.

In summary, the majority of children included in this study did follow the same sequence of stage development postulated by Piaget. Further research is required to determine the reasons for the failure of several children to do so.

QUESTION 3: Will learning disabled children diagnosed as reading or arithmetic or behavior problems or reading and arithmetic or reading, arithmetic and behavior problems be differentiated by stage of development on mathematical concepts tasks?

The one way analysis variance indicated no significant differences between the groups at either age level for the Conservation of Number test. The fact that the vast majority of children in this study were conservers can probably be related to the age range (six years nine months to fourteen years) of the children. At both age levels the ANOVA detected significant differences between the group means for the Seriation task. The Scheffé test found significant differences between the control group and the arithmetic disabled group at the younger age level and at the older age level significant differences were present between the control group and each of the arithmetic, behavior and combined reading and arithmetic disability groups.

The arithmetic dysfunction group at both age levels experienced great difficulty with the Seriation task. Operational seriation according to Piaget (1952) involves the synthesis of cardination and ordination and is independent of changes in the field of perception. The child must coordinate both the additive and subtractive aspects of two inverse relations $s > t$ and $s < t$. The relations involved have

become reversible. The child who is not operational on the Seriation task may not grasp the relationship between 8 = 3+5 and 8-3 = 5. This could account for part of the problem experienced by the arithmetic group. The Scheffé test also detected significant differences between the control group and the arithmetic and reading dysfunction group on the Seriation task. The previous discussion relating poor performance on the Seriation task to arithmetic may also pertain to this group. Elkind (1969) had suggested that poor performance on the seriation task might be related to reading difficulties: "The ability to construct spatial seriations ... is clearly essential for comprehending the grammatical significances of word order" (p. 202).

The control group and the behavior disability group also differed significantly at the older age level on the Seriation task. The (Lester et al., 1970; Dudek, 1972 and Dudek and Dyer 1972) research had indicated that children with behavioral problems might experience difficulties with the Seriation task. Piaget (1952) stressed that flexibility and reversibility of thought is necessary for operational seriation. Flexibility of thought implies the ability to consider problems from different points of view and thus would seem to be linked to egocentrism. However, of the seven children in this group who were preoperational on the Seriation task five were operational on the "perspectives" task indicating that they could look at problems from different viewpoints. It is probably a factor other than egocentrism that is delaying operational seriation in these children.

QUESTION 4: Will learning disabled children diagnosed as reading or arithmetic or behavior problems or reading and arithmetic or reading, arithmetic and behavior problems be differentiated by stage of development on classification tasks?

No significant differences were detected by the ANOVA for classification tests among the younger children. At the older age level the ANOVA detected significant differences for the tests of Multiplicative Classification and the Duality Principle. The Scheffé test, however, did not detect any significant differences between group means on the Multiplicative Classification test at a probability level $< .10$. For the Duality Principle, however, the Scheffé indicated significant differences between the control and all of the dysfunction groups. All of the older control children but two had reached the formal operational stage for the Duality Principle. None of the 52 older children in the dysfunction groups were formal operational and only three of them had reached Stage III where they demonstrated an ability to handle the general inclusion questions. Of the remaining learning disabled children, 36 were at Stage II, able to handle straight negation questions and 13 at Stage I, only able to achieve the spontaneous classification of the animals. The development of the logical structures required to cope with the Duality Principle test appears to be delayed in the vast majority of older learning disabled children involved in this study.

QUESTION 5: Will learning disabled children diagnosed as reading or arithmetic or behavior problems or reading and arithmetic or reading, arithmetic and behavior problems be differentiated by stage of development of spatial tasks?

The ANOVA detected significant differences between the group means of the younger children for two of the spatial tasks, Localization of Topographical Positions, and Coordination of Perspectives. At the older age level the ANOVA detected significant differences for the Concepts of Left and Right and the Coordination of Perspectives.

At the younger age level, the Scheffé test revealed significant differences between the control group and the reading and arithmetic disabled group on the test for Topographical Positions. All of the control children were operational on the task but only one third of the learning disabled children had achieved this status. The children with the combined reading and arithmetic disability were obviously experiencing much difficulty in attempting to coordinate the left-right and before-behind relationships that this task presents. Three of the children in this dysfunction group also departed from the developmental sequence expected for the task. As mentioned previously, the ability to deal with the Localization of Topographical Positions test has been related to the egocentricity of the child and it involves the child's ability to handle the concepts of left and right. All of the control children showed signs of at least partial decentration on

"perspectives" task, but this was true of only four of the nine children in the dysfunction group. Four of the ten control children were operational on the Concepts of Left and Right but none of the dysfunction children were operational on this task. Perhaps the weak concepts of left and right and the high degree of egocentricity influenced the performance of the disabled children on the Topographical Positions task. The influence of these two factors may have outweighed the influence of the topographical cues present in the task. The Scheffé test also indicated significant differences at the younger age level between the control group and the combined reading, arithmetic and behavior disability group on the Coordination of Perspectives test. Whereas all of the ten control children demonstrated at least partial decentration on the "perspectives" test only two of the ten dysfunction children indicated any decentration. All of the control children were operational on Topographical Positions as compared with five of the ten dysfunction children. Again, four of ten control children were operational on the Concepts of Left and Right but none of the dysfunction children were operational on this task. It would appear that there is a developmental lag regarding the ability of the children with multiple handicaps at the younger age level to deal with cognitive space as described by Piaget.

At the older age level the Scheffé test detected significant differences between the control group and the reading and arithmetic dysfunction group with respect to the Concepts of Left and Right test. Nine of the ten control children were operational on this

task as compared with two of the 12 children in the dysfunction group. Comparing the performance of these groups on the other spatial tasks, all of the control children were operational on Topographical Positions and nine of the 12 dysfunction children were operational on the same task. Regarding the Coordination of Perspectives, nine of the control group were operational and one indicated partial decentration. Of the reading and arithmetic disability group only two were operational, four more showed signs of partial decentration and six were completely egocentric. Compared to the control the dysfunction group shows a general lag in the development of cognitive space.

Significant differences occurred between the older groups on the test of Coordination of Perspectives. The Scheffé test revealed differences between the control and arithmetic group, the control and reading and arithmetic group, the control and the combined reading, arithmetic and behavior disability group and between the reading disability and the reading and arithmetic disability group. Again, it is chiefly the multiply handicapped groups who are experiencing difficulty with cognitive space. However, it is also of some interest here to speculate on the importance of arithmetic difficulties among these children. In all cases where the control group differs from a dysfunction group, arithmetic is involved. However, there is also a significant difference between the performance of the reading disability group and the reading and arithmetic disability group on the "perspectives" test. It is suggested that in these older

children who are having problems with cognitive space, that the arithmetic problem is a very important factor.

QUESTION 6: Will the older children become operational on the Piagetian tasks but continue to experience academic difficulties?

The vast majority of the older control children were operational on all of the Piagetian tasks. Some of the children in the older dysfunction groups were operational on the tasks, others were not. The children in the dysfunction groups who were operational on the tasks continued to experience academic difficulties. This would indicate as Lovell (1961) suggests that operational performance on Piagetian tasks may be necessary but not sufficient for academic achievement.

Summary of Conclusions

The major findings of this investigation were:

1. The children called learning disabled with few exceptions followed the sequence of stages described by Piaget for logico-mathematical and spatial development in normal children.
2. At the younger age level, significant differences existed between the performance of the control group and several dysfunction groups on the Seriation task, a test for mathematical concepts, and two of the spatial development tests, Topographical Positions and the Coordination of Perspectives.

3. At the older age level, significant differences existed between the performance of the control group and several dysfunction groups on the Seriation task, a test for mathematical concepts; the Duality Principle, a test of logical thinking; and two tests of spatial development, the Concepts of Left and Right and the Coordination of Perspectives.
4. A number of the older children called learning disabled were operational on the Piagetian tasks but continued to experience academic difficulties.
5. Arithmetic appears to be the most serious type of disability, in that more areas of deficit seem to be related to it. The areas of deficit are Seriation, Multiplication of Classes, Concepts of Left and Right and Coordination of Perspectives. When arithmetic is included in combined disabilities, the combined disabilities usually reflect the same pattern of deficit as the single arithmetic disability. When arithmetic did not appear to be as closely related to a specific deficit, as in Topographical Positions, the combined disability reflected the single reading disability. The Koppitz (1971) research indicated that an arithmetic disability is a very serious problem. Comparing the academic achievement of children at the time of admission to a Learning Disability class with their status five years later,

Koppitz found that pupils who were able to return to regular classes were better readers. No significant differences were found in the arithmetic achievement of students returning to regular classes and those remaining in the Learning Disability program. The arithmetic achievement of both of these groups, however, did differ significantly from that of children who eventually required psychiatric care. The latter group had also shown poor integration on the Bender Gestalt Test. "Research has shown a close correlation exists between performance on the Bender Gestalt Test and achievement in arithmetic and that both are related to children's integrative ability and overall behavior" (p. 46). The results of the present study may reflect the problem described by Koppitz.

Recommendations

The following recommendations are based upon conclusions drawn from this study.

1. Elementary school teachers should be made aware of the concepts defined by Piaget, of the tasks used to measure the development of these concepts and of the relationship between performance on Piagetian tasks and academic achievement.

2. More research should be carried out in terms of the feasibility of teaching basic Piagetian concepts and the manner in which these concepts could best be taught. It would perhaps be helpful to experiment with the teaching of the concepts within the context of the elementary curriculum and in isolation and to subsequently determine where maximum transfer occurs. The question of whether teaching Piagetian concepts will precipitate success in reading and arithmetic remains to be answered.
3. The seriousness of an arithmetic disability should be stressed to teachers. More research is required to detect the specific nature of arithmetic disabilities. Koppitz (1971) referred to a relationship which seems to exist between a basic visual motor integrative disability with respect to arithmetic and behavior problems. It is perhaps the very pervasiveness of this type of disability which is causing the child to be so disabled. The relationship between perceptual and cognitive space as it pertains to arithmetic requires investigation.
4. The results of this study can only be used to indicate trends which may exist as to the performance of children with specific learning disabilities on Piagetian tasks. The numbers of subjects involved in the study were too small to make any generalizations to a larger

population. This research could be extended to a more comprehensive investigation of larger numbers of children with specific types of learning disabilities.

BIBLIOGRAPHY

Aebli, H. "Egocentrism" (Piaget) not a phase of mental development but a 'substitute solution' for an insoluble task. Pedagogica Europaea, 1967, 3, 97-103.

Almy, M. Longitudinal studies related to the classroom. In M.F. Rosskopf, L.P. Steffe and S. Taback, Eds., Piagetian Cognitive-Development Research and Mathematical Education. Washington: National Council of Teachers of Mathematics, Inc., 1971.

Almy, M. Language, thought and the precursors of reading, 1972, Unpublished Paper.

Almy, M., Chittenden, E. and Miller, P. Young Children's Thinking: Studies of Some Aspects of Piaget's Theory. New York: Teacher's College Press, 1966.

Almy, M. and Associates. Logical Thinking in Second Grade. New York: Teacher's College Press, 1970.

Anthony, E.J. Six applications de la theorie genetique de Piaget a la theorie et a la practique psychodynamique. Revue Suisse Psychologie, 1956, 15, 269-277.

Anthony, E.J. Piaget et le clinician. Themes Piagetian et Epistomologie Centique. Paris:1966.

Beard, R.M. Further studies in concept development. Educational Review, 1964, 17, 41-48.

Bearison, D.J. Is "school achievement" enhanced by teaching children operational concepts? 1974. In G.I. Lubin, J.F. Magary and M.K. Poulsen, Eds., Proceedings Fourth Interdisciplinary Seminar: Piagetian Theory and its Implications for the Helping Professions. Los Angeles: University of Southern California, 1975.

Bell, S.M. The relationship of infant-mother attachment to the development of the concept of object permanence, 1968. Unpublished Ph.D. Thesis, Johns Hopkins University.

Benton, A.L. Right-Left Discrimination and Finger Localization. New York: Holber Harper, 1959.

Borke, H. Piaget's mountains revisited: Changes in the egocentric Landscapes, Developmental Psychology, 1975, 11, 2, 240-243.

Brekke, B. and Williams, J.D. Reversibility preceding conservation and reading readiness. Journal of Psychology, 1975, 90, 2, 191-196.

Brodzinsky, D.M., Jackson, J.P. and Overton, W.F. Effects of perceptual shielding in the development of spatial perspectives. Child Development, 1972, 43, 3, 1041-1046.

Bryden, M.P. Auditory-visual and sequential-spatial matching in relation to reading ability. Child Development, 1972, 43, 824-832.

Cathcart, W.G. The relationship between primary students' rationalization of conservation and their mathematical achievement. Child Development, 1971, 42, 755-765.

Clements, D.S. Minimal brain dysfunction in children, Public Health Services Publications, No. 415, Washington, D.C.: U.S. Department of Health, Education and Welfare, 1966.

Coleman, R.I. and Deutsch, C.P. Lateral dominance and right-left disctimination: comparison of normal and retarded readers. Perceptual and Motor Skills, 1964, 19, 43-50.

Concannon, J. A review of research on haptic perception. Journal of Educational Research, 1970, 63, 6, 250-252.

Crutchfield, M.A. Conservation training and school readiness, 1974. In G.I. Lubin, J.F. Magary and M.K. Poulsen, Eds., Proceedings Fourth Interdisciplinary Seminar: Piagetian Theory and its Implementations for the Helping Professions. Los Angeles: University of Southern California, 1974.

Dasen, P.R., de Lacey, P.R. and Seagrim, G.N. An investigation of reasoning ability in adopted and fostered Aboriginal children. In G.E. Kearney, P.R. de Lacey and Davidson, Eds., The Psychology of Aboriginal Australians. Queensland University Press, 1972.

Denney, D.R. Relationship of three cognitive style dimensions to elementary reading abilities. Journal of Educational Psychology, 1974, 66, 702-709.

Dodwell, P.C. Children's understanding of number and related concepts. Canadian Journal of Psychology, 1960, 14, 191-205.

Dodwell, P.C. Children's understanding of number concepts: Characteristics of an individual and of a group test. Canadian Journal of Psychology, 1961, 15, 1, 29-36.

Dodwell, P.C. Relations between the understanding of the logic of classes and of cardinal number in children. Canadian Journal of Psychology, 1962, 16, 152-160.

Dodwell, P.C. Children's understanding of spatial concepts. Canadian Journal of Psychology, 1963, 17, 141-161.

Dudek, S.Z. A longitduinal study of Piaget's developmental stages and the concept of regression I, Journal of Personality Assessment, 1972, 36, 4, 380-389.

Dudek, S.Z. and Dyer, G.B. A longitudinal study of Piaget's developmental stages and the concept of regression II, Journal of Personality Assessment, 1972, 36, 5, 468-478.

Dudek, S.Z., Lester, E.P. Goldberg, J.S. and Dyer, G.B. Relationship of Piaget's measures to standard intelligence and motor scales. Perceptual and Motor Skills, 1969, 28, 351-362.

Eiser, C. Recognition and inference in the coordination of perspectives. British Journal of Educational Psychology, 1974, 44, 3, 309-312.

Elkind, D. The development of quantative thinking: A systematic replication of Piaget's studies. Journal of Genetic Psychology, 1961(a), 98, 37-46.

Elkind, D. Children's discovery of the conservation of mass, weight, and volume: Piaget replication study II. Journal of Genetic Psychology, 1961(b), 98, 219-227.

Elkind, D. The development of additive composition of classes in the child: Piaget replication study III. Journal of Genetic Psychology, 1961(c), 99, 51-57.

Elkind, D. Piaget's theory of perceptual development: Its applications to reading and special education. Journal of Special Education, 1967, 1, 357-361.

Elkind, D. Reading, logic and perception. An approach to reading instruction. In J. Helmuth, Ed., Educational Therapy. (Vol. 2) Seattle: Special Child Publications, 1969.

Elkind, D. and Deblinger, J. Perceptual training and reading development in disadvantaged children. Child Development, 1969, 40, 11-19.

Elkind, D. and Scott, L. Studies in perceptual development: I The decentering of perception. Child Development, 1962, 33, 619-630.

Elkind, D. and Weiss, J. Studies in perceptual development: III, Perceptual exploration. Child Development, 1967, 38, 553-561.

Elkind, D. Koegler, R.R., and Go, E. Studies in perceptual development: II, Part-whole perception. Child Development, 1964, 35, 81-90.

Elkind, D., Larson, M., and Van Doorminck, W. Perceptual decentration learning and performance in slow and average readers. Journal of Educational Psychology, 1965, 56, 50-56.

Estes, B.W. Some mathematical and logical concepts in children. Journal of General Psychology, 1956, 88, 219-232.

Fishbien, H.D., Lewis, S. and Keiffer, K. Children's understanding of spatial relations: Coordination of perspective. Developmental Psychology, 1972, 7, 1, 21-23.

Fisher, G.H. Developmental features of behavior and perception. British Journal of Educational Psychology, 1965, 35, 69-78.

Flavell, J.H. The Developmental Psychology of Jean Piaget. New York: D. Van Nostrand Company, Inc., 1963.

Flavell, J.K., Botkin, P.T., Fry, C.L., Wright, J.W. and Jarvis, P.E. The Development of Role-Taking and Communication Skills in Children. New York: Wiley, 1968.

Foorman, B.R. A look at reading diary studies: The state of the art and some implications from cognitive-developmental theory, 1974. In G.I. Lubin, J.F. Magary and M.K. Poulsen, Eds., Proceedings Fourth Interdisciplinary Seminar: Piagetian Theory and its Implications for the Helping Professions. Los Angeles: University of Southern California, 1975.

Freyberg, P.S. Concept development in Piagetian terms in relation to school attainment. Journal of Educational Psychology, 1966, 57, 164-168.

Garner, J. and Plant, E.L. On the measurement of egocentrism: A replication and extension of Aebli's findings. British Journal of Educational Psychology, 1972, 42, 79-83.

Garrettson, J. Cognitive style and classification. Journal of General Psychology, 1971, 119, 79-87.

Ginsburg, H. and Opper, S. Piaget's Theory of Intellectual Development: An Introduction. Ner Jersey, Prentice Hall, Inc., 1969.

Goldschmid, M.L. Different types of conservation and their relation to age, sex, IQ MA and vocabulary, Child Development, 1967, 38, 1229-12246.

Goldschmid, M.L. The relation of conservation to emotional and environmental aspects of development. Child Development, 1968, 39, 579-589.

Goldschmid, M.L. and Bentler, P.M. The dimesions and measurement of conservation. Child Development, 1968(a), 39, 787-802.

Goldschmid, M.L. and Bentler, P.M. Manual: Concept Assessment Kit - Conservation. San Diego, California Education and Industrial testing Service, 1968(b).

Green, D.R., Ford, M.P. and Flamer, G.B. Measurement and Piaget. New York: McGraw Hill, 1971.

Hammill, D. Training visual perceptual processes. Journal of Learning Disabilities, 1972, 5, 552-562.

Harris, A.J. Lateral dominance, directional confusion and reading disability. Journal of Psychology, 1957, 44, 283-294.

Harris, L.J. and Stommen, E.A. The role of front-back features in children's 'front', 'back' and 'beside' placement of objects. Merrill-Palmer Quarterly, 1972, 18, 259-271.

Hatheway, W.E. and Hatheway - Theunissen, A. The unique contributions of Piagetian measurement to diagnosis, prognosis and research of children's mental development, 1974. In G.I. Lubin, J.F. Magary, and M.K. Poulsen, Eds., Proceedings Fourth Interdisciplinary Seminar: Piagetian Theory and its Implications for the Helping Professions, Los Angeles: University of Southern California, 1975.

Hill, B. 'Review: Piaget', Parks One, Two and Three. Times Editorial Supplement, 1972, 11th Feb., 18th Fe., and 25th Feb., respectively.

Hood, B. An experimental study of Piaget's theory of the development of number in children. British Journal of Psychology, 1962, 5, 3, 273-286.

Housch, J. Piaget's theory of cognitive development: Applications to research in reading acquisition. 1972, Unpublished Paper.

Houssidas, L. Coordination of perspectives in children. Archives Fur Die Gesamte Psychologie, 1965, 117, 319-326.

Howell, R.W. Evaluation of cognitive abilities of emotionally disturbed children: An application of Piaget's theories. Dissertation Abstracts International, 1972, 32, 9A, 5037-5038.

Inhelder, B. The Diagnosis of Reasoning in Mentally Retarded. (Rev. Ed.), New York: John Day, 1968.

Inhelder, B., Sinclair, H, and Bovet, M. Learning and the Development of Cognition. London: Routledge and Kegan Paul Ltd., 1974.

Jorgenson, G.W. and Hyde, E.M. Auditory-integration and reading performance in lower-social-class children. Journal of Educational Psychology, 1974, 66, 702,709.

Kaufman, A.S. Piaget and Gesell: A psychometric analysis of tests built from their tasks. Child Development, 1972, 42, 1341-1360.

Kaufman, A.S. and Kaufman, N.L. Tests built from Piaget's and Gesell's tasks as predictors of first-grade achievement. Child Development, 1972, 43, 521-535.

Kershner, J.R. Visual-spatial organization and reading: Support for a cognitive-developmental interpretation. Journal of Learning Disabilities, 1975, 8, 37-42.

Kirk, S.A. The Illinois Test of Psycholinguistic Abilities: its origins and implications. In J. Helmuth, Ed., Learning Disorders, (vol. 3) Seattle: Special Child Publications, 1968.

Klees, M. and LeBrun, A. Analyses of the figurative and operative processes of thought of 40 dyslexic children. Journal of Learning Disabilities, 1972, 5, 3890396.

Kofsky, E. A scalogram study of classificatory development. Child Development, 1966, 37, 191-204.

Koppitz, E.M. Children With Learning Disabilities A Five Year Follow-Up Study. New York: Grune and Stratton, 1971.

Laurendeau, M. and Pinard, A. The Development of the Concept of Space in the Child. New York: International University Press, 1970.

LeBlanc, J.F. The performance of first-grade children in four levels of conservation of numerousness and three IQ groups when solving arithmetic subtraction problems. Ph.D. Dissertation, University of Wisconsin, 1968.

Lefebre, A. A propos d'un cas de "Dyscalculie" de la reeducation a la psychotherapie. Perspectives Psychiatriques, 1970, 4, 30, 39-56.

Lerner, S., Bie, I, and Lehrer, P. Concrete-operational thinking in mentally-ill adolescents. Merrill-Palmer Quarterly, 1972, 287-291.

Lester, E.P., Muir, E.D. and Dudek, S.Z. Cognitive structure and achievement in the young child. Canadian Psychiatric Association Journal, 1970, 15, 279-287.

Lovell, K. A follow-up study of some aspects of the work of Piaget and Inhelder on the child's conception of space. British Journal of Educational Psychology, 1959, 29, 104-117.

Lovell, K., The Growth of Basic Mathematical and Scientific Concepts in Children. London: University of London Press, 1961.

Lovell, K. Intellectual growth and understanding in mathematics. Journal for Research in Mathematics Education, 1972, May, 164-182.

Lovell, K., Shapton, D. and Warren, N.S. A study of some cognitive and other disabilities in backward readers of average intelligence as assessed by a non-verbal test. British Journal of Educational Psychology, 1964, 34, 58-64.

Lubin, G.I., Magary, J.F., and Poulsen, M.K. Eds., Proceedings Fourth Interdisciplinary Seminar: Piagetian Theory and its Implications for the Helping Professions. Los Angeles, University of Southern California, 1975.

MacKay, C.K. Brazendale, A.H. and Wilson, L.F. Concepts of horizontal and vertical: A methodological note. Developmental Psychology, 1972, 7, 3, 232-237.

McManis, D. Conservation of identity and equivalence of quantity in retardates. Journal of Genetic Psychology, 1969, 115, 63-68.

Modgil, S. The relation of emotional adjustment to the conservation of number. 1969. In S. Modgil, Ed., Piagetian Research A Handbook of Recent Studies, Windsor, Berks: NFER Publishing Co. Ltd., 1974.

Modgil, S. Piagetian Research A Handbook of Recent Studies. Windsor, Berks: NFER Publishing Co. Ltd., 1974.

Murray, F.B. Acquisition of conservation through social interaction. Developmental Psychology, 1972, 6, 1-6.

Neale, J.M. Egocentrism in institutionalized and non-institutionalized children. Child Development, 1966, 37, 97-101.

Page, E. Haptic perception: A consideration of one of the investigations of Piaget and Inhelder. Educational Review, 1959, 11, 115-125.

Peel, E.A. Experimental examination of some of Piaget's schemata concerning children's perception and thinking and a discussion of their educational significance. British Journal of Educational Psychology, 1959, 29, 89-103.

Piaget, J. Judgment and Reasoning in the Child. London: Routledge and Regan Paul Ltd., 1928.

Piaget, J. The Psychology of Intelligence. London: Routledge and Regan Paul Ltd., 1950.

Piaget, J. The Child's Conception of Number. New York: W.W. Norton and Co. Ltd., 1952.

Piaget, J. The Construction of Reality in the Child. New York: Basic Books, 1954.

Piaget, J. Les Mechanismes Perceptifs. Paris: Presses Universitaires de France, 1961.

Piaget, J. The stage of intellectual development of the child. Bulletin of the Menninger Clinic, 1962(a), 26, 3, 120-128.

Piaget, J. The relation of affectivity to intelligence in the mental development of the child. Bulletin of the Menninger Clinic, 1962(b), 26, 3, 129-137.

Piaget, J. Will and action. Bulletin of the Menninger Clinic, 1962(c), 26, 3, 138-145.

Piaget, J. Six Psychological Studies. New York: Random House, Vintage Books, 1967.

Piaget, J. A structural foundation for tomorrow's education. Prospects, Quarterly Review of Education. 1972, II, I, 12-27.

Piaget, J. and Inhelder, B. The Child's Conception of Space. London: Routledge and Kegan Paul Ltd., 1956.

Piaget, J. and Inhelder, B. The Early Growth of Logic in the Child. London: Robtledge and Kegan Paul, 1964.

Pimm, J.B. The clinical use of Piagetian tasks with emotionally disturbed children. 1974. In G.I. Luvin, J.F. Magary and M.K. Poulsen, Eds., Proceedings Fourth Interdisciplinary Seminar: Piagetian Theory and its implications for the Helping Professions. Los Angeles: University of Southern California, 1975.

Pimm, J.B. and McClure, G. A screening test for early detection of emotional disturbance in a public school setting. Exceptional Children, 1967, May, 647-648.

Rosskopf, M.F., Staffe, L.P. and Taback, S. Eds., Piagetian Cognitive-Development-Research and Mathematical Education. Washington: National Council of Teachers of Mathematics, Inc., 1971.

Rubin, K.H. Egocentrism in childhood: A unitary construct? Child Development, 1973, 44, 1, 102-110.

Rutter, M.L. A children's behavior questionnaire for completion by teachers: Preliminary findings. Journal of Child Psychology and Psychiatry, 1967, 8, 1-11.

Rutter, M.L. The reliability and validity of the psychiatric assessment of the child: Interview with the child. Child Scales A and B. British Journal of Psychology, 1968, 114, 563-579.

Sabatino, D.A. and Hayden, D.L. Psycho-educational study of related behavioral variables with children failing the elementary grades. Journal of Experimental Education, 1970, 38, 40-57.

Sarason, S.B. A test-anxiety scale for children. Child Development, 1958, 29, 105-113.

Satz, P. Rardin, D. and Ross, J. An evolution of a theory of specific developmental dyslexia. Child Development, 1971, 42, 2009-2021.

Schantz,C.W. and Smock, C.D. Development of distance conservation and the spatial coordinate system, Child Development, 1966, 37, 943-948.

Schantz, C.W. and Watson, J.S. Assessment of spatial egocentrism through expectancy violation. Psychonomic Science, 1970, 19, 2, 93-94.

Shoben, E.J. (Jr.) The assessment of parental attitudes in relation to child adjustment. Genetic Psychological Monography (U.S.A.) 1949, 39, 102-148.

Sohns, M.L. A comparison between certain Piagetian logical thinking tasks and the subtraction ability of first, second and third grade children, 1974. In G.I. Lubin, J.F. Magary, and M.K. Poulsen, Eds., Proceedings Fourth Interdisciplinary Seminar: Piagetian Theory and Its Implication for the Helping Professions. Los Angeles: University of Southern California, 1975.

Steffe, L.P. The performance of first grade children in four levels of conservation of numerousness and three IQ groups when solving arithmetic addition problems. Research and Development Centre For Cognitive Learning Technical Report No. 14. Madison: University of Wisconsin, 1966.

Stephens, W.B., McLaughlin, J.A., Miller, C.K. and Glass, G.V. Factorial structures of selected psychoeducational measures and Piagetian reasoning assessments. Developmental Psychology, 1972, 6, 343-347.

Stommel, L. The prediction of first grade achievement in arithmetic based on Piaget's theory of the formation of number concept. Unpublished Doctoral Dissertation, University of California, Berkeley, 1966.

Van Engen, H. and Steffe, L.P. First grade children's concept of addition of natural numbers. Research and Development Centre for Learning and Re-Education, Technical Report No. 5, Madison: University of Wisconsin, 1966.

Wheatley, G.H. Conservation, Coordination and counting as factors in mathematics achievement among first grade students. Doctoral Dissertation, University of Delaware, 1967.

Wheatley, G.H. Conservation cardination and counting as factors in mathematics achievement. American Educational Research Association. Feb., 1968.

Whyte, L.A., The development of classification ability in children of below average intelligence. Unpublished Doctoral Dissertation, Columbia University, 1967.

Winer, B.J., Statistical Principles in Experimental Design. New York: McGraw-Hill Book Company, 1962.

Wohlwill, J.F. A study of the development of the number concept by scalogram analysis. Journal of Genetic Psychology, 1960, 97, 345-377.

APPENDIX A

THE TEST BATTERY

NAME: ____________________ SCHOOL: ________________ DATE: ________

CONSERVATION OF NUMBER.

Material: (orientation and task 1) Nine blue blocks, a box containing yellow blocks; (task 2) 20 blue blocks and 20 yellow blocks.

Procedure: Orientation task: E presents the 9 blue blocks spaced out in a line.

$\boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}$

E then presents the box containing the yellow blocks and says;

"Make a line exactly like the blue line."

If S has difficulty making this one-to-one correspondence, he is given help. When the two lines are equal in number, S is asked:

"Are there the same number of blue blocks as yellow ones?"

Following the child's answer, one blue block is removed and the question is repeated.

Then, one yellow block is removed. One yellow is added and two blues removed. Each time the question is repeated.

Finally the 9 blues and 9 yellows are aligned and equality established.

$\boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}\ \boxed{B}$

$\boxed{Y}\ \boxed{Y}\ \boxed{Y}\ \boxed{Y}\ \boxed{Y}\ \boxed{Y}\ \boxed{Y}\ \boxed{Y}\ \boxed{Y}$

Comments on orientation:

Understood throughout ____________________

Prompting needed ____________________

Doubtful if understood ____________________

Other ____________________

Task 1: (a) The blue blocks are pushed together:

B B B B B B B B B

Y Y Y Y Y Y Y Y Y

S is asked:

"What about now?" If S does not understand, rephrase the question: "Are there more blue blocks than yellow ones, or are there more yellow than blue, or are they the same?"

Response: ______________________________

"Why do you think so?" ______________________

(b) The blue blocks are left pushed together and the yellow ones are scrambled:

B B B B B B B B B

Y Y Y

Y Y Y

Y Y Y

"What about now? Are there more blue blocks than yellow ones, or are there more yellow ones than blue, or are they the same?"

Response ______________________________

"Why do you think so?" ______________________

Task 2: Twenty blue blocks are spread out and 20 yellow blocks are lined up one-to-one correspondence

B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

(a) Understanding of equality is checked: "Are there the same number of blue blocks as yellow blocks?"

Response ______________________________

"Why do you think so?" ____________________

(b) The blue blocks are pushed together as in the task (1a). E asks:

"What about now?" Are there more blue blocks than yellow blocks, or are there more yellow than blue, or are they the same?"

Response ______________________________

"Why do you think so?" ____________________

(c) The blue blocks are left pushed together and the yellow ones are scrambled as in task (1b). E asks:

"What about now? Are there more blue blocks than yellow ones, or are there more yellow than blue, or are they the same?"

Response ______________________________

"Why do you think so?" ____________________

NAME: ______________________ SCHOOL: ____________________ DATE: ___________

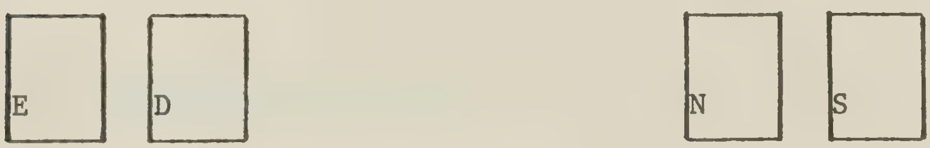
SERIATION.

Material: Two sets of 10 cards, the drawings in graduated sizes, the largest being at least twice as big as the smallest. The drawings are of vases and a corresponding set of flowers. The sets are not drawn to the same scale. Each card is coded so that the cards, when placed in correct order, spell words, vases read EDUCATIONS and flowers read COMPLEXITY.

Procedure: (A) First Seriation Task.

E shows the cards to S and says:

"HERE ARE SOME PICTURES OF VASES. THIS IS THE BIGGEST ONE AND WE WILL PUT IT HERE. THIS IS THE SMALLEST ONE AND WE WILL PUT IT HERE." (about 20" apart). "THIS IS THE NEXT LARGEST ONE AND WE WILL PUT IT HERE; THIS IS THE NEXT SMALLEST ONE AND WE WILL PUT IT HERE."



E spreads out the remaining six cards and asks:

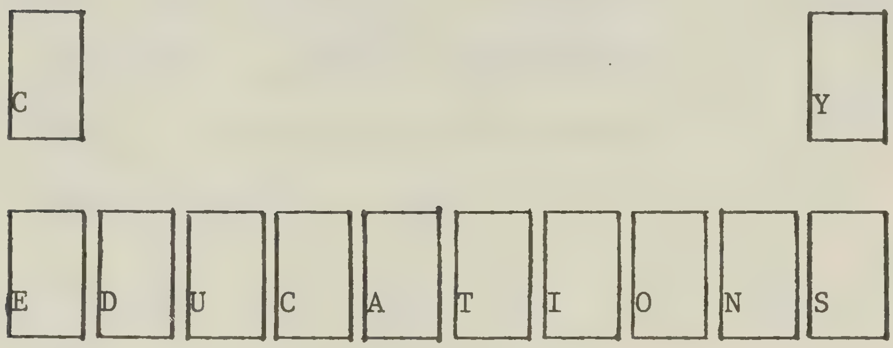
"CAN YOU ARRANGE THE REST?" PUT THEM IN ORDER GOING FROM THE BIGGEST TO THE SMALLEST. TELL ME WHEN YOU HAVE FINISHED."

Order of cards ____

If any of the pictures are in the wrong position, E helps S to correct them.

Second Seriation Task

E places the pictures of the largest and smallest flowers above the largest and smallest vases.



S is asked:

"CAN YOU ARRANGE THE REST OF THESE PICTURES SO THAT EACH FLOWER GOES WITH THE RIGHT VASE? TELL ME WHEN YOU HAVE FINISHED."

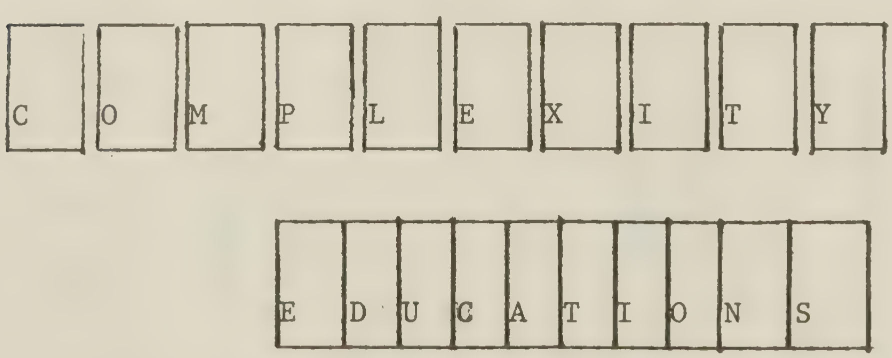
Order of cards: <u>C</u> <u>Y</u>

<u>E</u> <u>D</u> <u>U</u> <u>C</u> <u>A</u> <u>T</u> <u>I</u> <u>O</u> <u>N</u> <u>S</u>

If any cards are in the wrong position, E helps S to correct them.

(B) Ordering Task:

E says, "NOW WATCH WHAT I DO." The row of vases is pushed close together and the pictures of the flowers are spread out and moved to the left, until the fourth flower (P) is above the first vase (E).



Pointing to each of the following vases the child is asked, "CAN YOU TELL ME WHICH FLOWER BELONGS TO THIS VASE?"

Vase 4 (C) ___ "WHY DO YOU THINK SO?" ______________

Vase 7 (I) ___ "WHY DO YOU THINK SO?" ______________

Vase 8 (O) ___ "WHY DO YOU THINK SO?" ______________

Method of selection for each task:[1]

Vase C ____________________

Vase I ____________________

Vase O ____________________

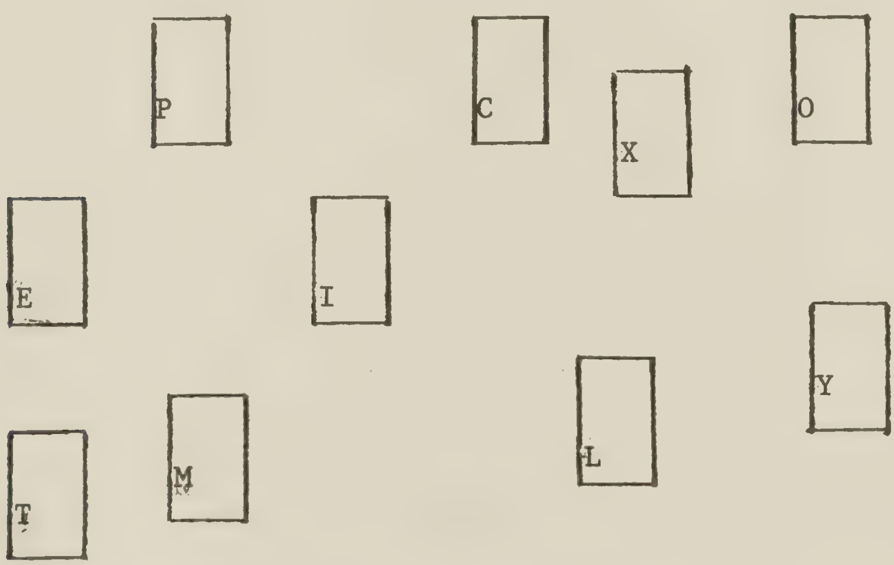
[1]ordination (a)

one-to-one correspondence (b)

other methods (c)

(C) Reordering Task:

E leaves the series of vases untouched, but scrambles the pictures of flowers:



E says: "THE FLOWERS ARE ALL MIXED UP NOW. CAN YOU FIND THE FLOWER THAT GOES WITH THIS VASE?" (Vase 6; i.e. T)

<u>Flower selected</u>:

<u>Method of selection</u>:

Reorders through card 1 ______________

Reorders series completely ______________

Visual estimate ______________

Random choice ______________

Other methods ______________

"Why did you choose that one?" ____________________

____

____

NAME: ____________________ SCHOOL: ______________ DATE: __________

ADDITIVE COMPOSITION OF CLASSES

Material: Twenty round wooden beads: 18 red and 2 white, a sheet of yellow paper, 2 boxes. A second complete set of wooden beads (18 red, 2 white) to use if S has to make the necklaces.

Training: Present a complete set of twenty beads laid out in disorder on the sheet of yellow paper. Instruct S to pick up some of the beads and look at them. Ask,

"WHAT ARE THEY?" ________________ "WHAT ARE THE BEADS MADE OF?"_______

"WHAT COLOR ARE THEY?" _________________

"IF I PUT THE RED BEADS IN THIS BOX, WILL THERE BE ANY BEADS LEFT?" ___

"SHOW ME WHAT WILL BE LEFT?" ____________ "AND IF I PUT THE WOODEN BEADS IN THE OTHER BOX WILL THERE BE ANY BEADS LEFT?" _______________

"WHY?" ____

If S answers no to this question ask:

"ARE THE RED BEADS MADE OF WOOD?" __________________________

"ARE THE WHITE BEADS MADE OF WOOD?" ________________________

Comment on training: Understood directions ________________

Prompting needed ________________ Doubtful if ever understood __________

Other __________________________

Testing procedure: Say to S,

(1) "IF I MADE A NECKLACE WITH ALL THE WOODEN BEADS, AND IF I MADE A NECKLACE OF ALL THE RED BEADS, WHICH NECKLACE WOULD BE LONGER?"_____

______________________ "WHY?" __________________________________

If S answers the red necklace ask: "BUT ARE THE RED BEADS WOODEN TOO?" ______________________

(2) "THEN IF I MADE A NECKLACE OF THE RED BEADS AND IF I MADE A NECKLACE OF THE WOODEN BEADS, WHICH NECKLACE WOULD BE LONGER." ______________________________

"WHY?" ________________________________

If S answers incorrectly, have him make the necklaces using the two complete sets of beads and compare them. Ask:

(3) "IF I MADE A NECKLACE OF THE WOODEN BEADS, AND IF I MADE A NECKLACE OF THE RED BEADS, WHICH NECKLACE WOULD BE LONGER?"

____

"WHY?" ________________________________

(4) "ARE THERE MORE WOODEN BEADS OR RED BEADS?" __________________

"WHY?" ________________________________

NAME: ____________________ SCHOOL: ________________ DATE: ____________

MULTIPLICATIVE CLASSIFICATION

Materials: Sixteen 2" shapes: 4 blue circles, 4 blue squares, 4 red circles and 4 red squares. Two 8" rods to form a 4 section box.

Procedure: Present the shapes in disorder, Say,

A. "PUT TOGETHER THOSE THAT ARE ALIKE, THOSE THAT GO TOGETHER."

Description of sorting: ____

____

____

B. Use one rod to form a two section box. Say,

"PUT SOME IN THIS BOX AND SOME IN THIS BOX." (indicate)

Grouping in box 1 ____

Grouping in box 2 ____

Sorting exhaustive? Yes ___ No ___ Describe remainder _________________

____

C. Use the two rods to form a four section box. Say,

"PUT TOGETHER THOSE THAT ARE ALIKE AND PUT THEM IN DIFFERENT PARTS OF THIS BOX."

Grouping:

Sorting exhaustive? Yes ___ No ___ Describe remainder ______________

____

D. Take out one of the partitions of the box used in C so that the blue squares will be in one half and the red squares in the other.

"CAN YOU PUT THESE (indicate blue squares) WITH THESE (indicate red squares)?"

Yes ______ WHY? ____

No ______ WHY NOT? ____

"CAN YOU PUT THESE (indicate blue circles) WITH THESE (indicate red circles)?"

Yes ______ WHY? ____

No ______ WHY NOT? ____

E. Replace the first partition and remove the second so that the shapes are subdivided into blue squares in one half and blue circles in the other half.

"CAN YOU PUT THESE (indicate blue squares) WITH THESE (indicate blue circles)?"

Yes ______ WHY? ____

No ______ WHY NOT? ____

"CAN YOU PUT THESE (indicate red squares) WITH THESE (indicate red circles)?"

Yes ______ WHY? ____

No ______ WHY NOT? ____

NAME: ______________________ SCHOOL: _________________ DATE: ____________

THE DUALITY PRINCIPLE

Material: Pictures, 2" X 2"; 5 different animals (cow, horse, pig, lamb, dog), 3 birds not ducks, 3 ducks.

Training: Present S with the material and say, "HERE ARE SOME PICTURES.

THIS (indicate duck) IS A ____________________________?

THIS (indicate bird not duck) IS A ____________________?

WHAT KINDS OF BIRDS (indicate the birds which are not ducks) ARE THESE? ___________, ____________, ____________.

HOW ARE THESE THREE (indicate ducks) ALIKE? __________

HOW ARE THESE THREE (indicate birds not ducks) ALIKE? ___________________

ARE THESE (indicate ducks) LIKE THESE (indicate birds not ducks) IN ANY WAY?" ____________________________________

If the response is not forthcoming say: "DID YOU KNOW THAT DUCKS ARE BIRDS? _________________

COULD WE MAKE ONE GROUP USING BOTH OF THESE LITTLE GROUPS? (indicate group of ducks and group of birds not ducks)

_________________________________ WHY? ___________________

ARE THE DUCKS BIRDS? ___________ WHY? ___________________

ARE THE DUCKS ANIMALS? _________ WHY? ___________________

ARE THE BIRDS ANIMALS? _________ WHY? ___________________

Comments: Understood questions _____________ Prompting needed ________

Doubtful if understood ______________________ Other ____________________

Test Procedures:

(1) Spontaneous classification. Present S with material and say,

"CAN YOU MAKE SOME GROUPS WITH ANIMALS THAT ARE LIKE EACH OTHER? FIND THE ANIMALS THAT ARE THE SAME KIND TWO OR MORE TIMES AND PUT THEM TOGETHER."

Description of classification ______________________________

____

"DIVIDE THE PICTURES INTO BIRDS AND OTHER ANIMALS."

Birds ____

Other Animals ______________________________________

"DIVIDE THESE (indicate birds) INTO DUCKS AND OTHER BIRDS."

Ducks ______________________ Other Birds __________________

(2) General questions on inclusion:

"ARE THERE MORE BIRDS OR MORE ANIMALS?" ______________________

"WHY?" ______________________

If S answers that "it is the same", ask "BUT IF ONE COUNTS ALL THE BIRDS AND THEN COUNTS ALL THE ANIMALS, WHERE WILL THERE BE MORE?"

More birds _____ More animals _____ "WHY?" ____________________

"ARE THERE MORE DUCKS OR MORE BIRDS?" More ducks ______________

More birds _____

"WHY ARE THERE MORE (________)?" ______________________________

If S answers that "it is the same", ask "BUT IF ONE COUNTS ALL THE DUCKS AND THEN COUNTS ALL THE BIRDS, WHERE WILL THERE BE MORE?"

More ducks _____ More birds _____ "WHY?" ______________________

(3) Questions on the duality principle:

"SHOW ME ALL THE THINGS WHICH ARE NOT DUCKS, AND ALL THOSE WHICH ARE NOT BIRDS."

Not ducks ____________________ Not birds ________________

"SHOW ME ALL THE THINGS WHICH ARE NOT BIRDS, AND ALL THOSE WHICH ARE NOT ANIMALS."

Not birds ____________________ Not animals _______________

"ARE THERE MORE LIVING THINGS WHICH ARE NOT DUCKS OR MORE LIVING THINGS WHICH ARE NOT BIRDS?"

More which are not ducks _________________

More which are not birds _________________

"WHY ARE THERE MORE WHICH ARE NOT (_____)?" _____________

"ARE THERE MORE LIVING THINGS WHICH ARE NOT BIRDS OR MORE LIVING THINGS WHICH ARE NOT ANIMALS?"

More which are not birds ________________

More which are not animals ______________

"WHY ARE THERE MORE WHICH ARE NOT (________)?" ___________

(4) If S has difficulty with form (2) or (3) questions, ask the following questions involving subtraction:

"IF ALL THE DUCKS IN THE WORLD WERE KILLED, WOULD THERE BE ANY BIRDS LEFT?"

Yes ______ No ______ "WHY?" ______________________________

"IF ALL THE BIRDS IN THE WORLD WERE KILLED, WOULD THERE BE ANY DUCKS LEFT?"

Yes _____ No _____ "WHY?" ______________________________

"IF ALL THE ANIMALS IN THE WORLD WERE KILLED, WOULD THERE BE ANY BIRDS LEFT?"

Yes _____ No _____ "WHY?" ________________________________

"IF ALL THE BIRDS IN THE WORLD WERE KILLED, WOULD THERE BE ANY ANIMALS LEFT?"

Yes _____ No _____ "WHY?" ________________________________

Comments: Understood questions ____________ Prompting needed ______

Doubtful if ever understood ________________ Other ________________

NAME: ____________________ SCHOOL: ______________ DATE: ____________

LOCALIZATION OF TOPOGRAPHICAL POSITIONS

Material: Two landscape boards (35 X 47 cm), identical in all respects and made of thin and smooth rectangular card-board, on which a road and railroad tracks are drawn, crossing near the centre and dividing the area into four sections of differing shapes and sizes; 10 houses (two identical series of five): one red (base: 7.5 X 2.5 cm; height: 3.5 cm); one yellow (base: 4.5 X 2.5 cm; height: 3.5 cm); three of different colors (blue, green, and yellow) but the same size (base 1.2 X 1.0 cm; height: 2.0 cm); two little men of modeling clay (about 3 cm high).

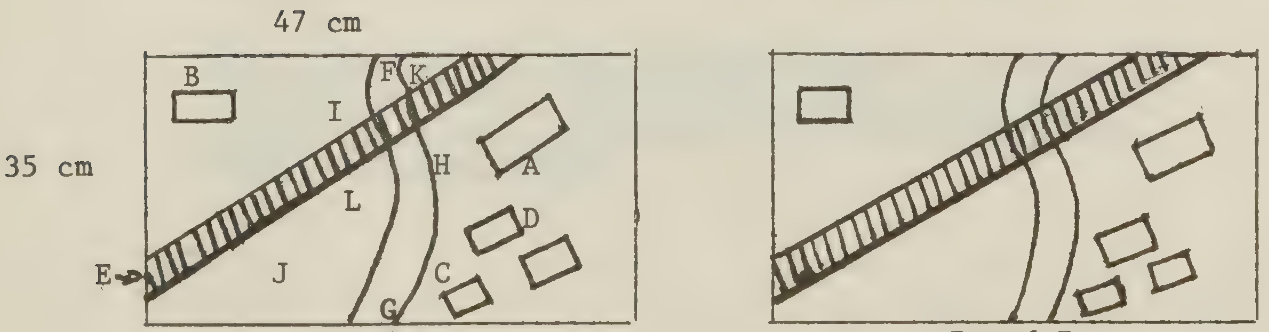
Procedure: General Directions: The examiner (E) and the subject (S) are seated across from each other, the landscapes being at first placed side by side and in the same direction. The examiner directs the child's attention to the identity of the two landscapes and makes him understand that one of them (on the child's left) belongs to the child and that the other one is his own. Examples are used to illustrate instructions and to establish that the child understands.

Problem 1: A: Examples:

Place the two landscape boards on the table in front of the child, and arrange them so that they face the same direction for the child. Then say:

"Now we are going to play a game. You see, we have two pictures that are alike.

S



Board A Board B

E

Here, there is a road for automobiles and, on the other picture, there is a road just like it. Then here is a railroad track for trains to travel on and, on the other picture, there is another one just like it. So you see, the two pictures are just alike. Now, if you like, I will take this picture here (point to board A, to the left in relation to the examiner) and you will have this picture over here (point to board B). Then one (board A) is mine and that one (board B) is yours.

Now we are going to put houses on our pictures. We will put the houses the same way on both pictures. See, here I am putting a red house. Now you should put a red house on your picture. There should be one at the same place so that the two pictures will be just alike (place the two houses with red roofs at point A).

Now, we are going to put a yellow house there (point to point B). Place the two houses with yellow roofs.

Now, we are going to put these smaller houses (the small blue, green, and yellow houses) there (point to C). Place the six smaller houses. (all houses have now been arranged.) Then make the child notice the identity of the boards, saying,

You see, now the two pictures are still just alike. You have houses just like mine and they are in the same place as mine are."

Present the two little men to the child, saying,

"See, I have a little man and I give you one just like mine. Now, I am going to put my man in my picture; and then after that, you are going to put your man in the same place in your picture. You must put your man just the way mine is. See, I am putting my man on the red roof (put it there); then you do the same thing; put your man on your red house, put him in the same position, in the same place.

Allow the child to place his man himself. However, if the child does not place his man on the red roof or if he does not seem to understand the instructions, place his man for him, saying:

"See, he goes there. Now he is at the same place as mine, he is placed just the way mine is. Do you understand?"

Once the child has clearly understood, present the second example saying:

"Now watch carefully. I am putting my man on my yellow house (put him there). You do the same thing I am doing: put your man in the same place, in the same position as mine. Put him just like mine on your picture."

If the child still does not understand what he is supposed to do, continue as in the first example. Before going on to the problems themselves, make sure the child fully understands the instructions. Repeat instructions when necessary and the examples. But do not place the man in any other positions than on the red roof and yellow roof.

The child understands the examples ______________________

The child does not understand the examples ______________

B. Problems:

Once the instructions are understood, E places his man, on board A, successively in the positions and in the order A, B, L, C, F, H, E, D, J, K, G, I, as indicated in the figure. Ask the child each time to locate his man in the same way on his board, saying:

"See now, I am putting my man here. You do the same thing; put your man in the same place on your picture; put your man in the same position so he will be just like mine."

While placing the man, never give any verbal indications such as, in front of the red house and on the road, etc. Simply say:

"I am putting him here (there, etc.)."

For each position indicate on the observation sheet the position where the child places his man, whether he makes any tentative moves or places him immediately. If there is any trial and error note the successive positions. Never suggest that his response is incorrect. Make only neutral remarks or evasive responses, whatever his response.

POSITION INDICATED BY E	POSITION(S) INDICATED BY S			MANNER OF POSITIONING IMMEDIATE	TENTATIVE	TRIAL AND ERROR
1 A	______	______	______	______	______	______
2 B	______	______	______	______	______	______
3 L	______	______	______	______	______	______
4 C	______	______	______	______	______	______
5 F	______	______	______	______	______	______
6 H	______	______	______	______	______	______
7 E	______	______	______	______	______	______
8 D	______	______	______	______	______	______
9 J	______	______	______	______	______	______
10 K	______	______	______	______	______	______
11 G	______	______	______	______	______	______
12 I	______	______	______	______	______	______

SCORE A - G = ; H - L = .

Problem 2: A. Examples

Remove the two men, leave the houses arranged in the same way on both boards, but turn board A 180 degrees, saying to the child:

"Now I am turning my picture because I can see better that way. You see, it is still just like yours, but it is turned. I still have a road the way you do (point to it), a railroad track for the trains, a red house, a yellow house, etc. (pointing to them one after the other). Okay, now, I am going to put my man on my picture again; then you put yours in the same place as mine, just like mine, at the same place in your picture. See, watch: I am putting my man on the red house. Put yours in the same place, in the same position in your picture."

Allow the child to work. If he does not understand, or if he does not put his man on the red house, put it there for him, saying:

"Watch, this is where he goes. There, he is in the same place as mine. Do you understand?"

Repeat the instructions when necessary, giving an example with the yellow house only if necessary.

The child understands the example(s) ____________________

The child does not understand the example(s) ___________

B. Problems:

Once the child understands the instructions, the examiner successively places his man, on board A, in the same positions as in problem 1 but in the order B, D, G, A, L, E, K, I, J, H, C, F. Ask the child each time to locate his man the same way on his board. Never give any verbal indications, but simply say that he is placed here or there, etc.

With the first mistake, but only for the first problem (position B) correct the child, saying:

Pay close attention. You see, I placed my man here (designating the correct position on board A); then you should place yours then (designating the corresponding position on board B). See, I am putting your man there (place it correctly). You see, now he is at the same place as mine. Pay close attention: it is hard because my picture is turned now. Okay, you understand? Always try to put your man at the same place as mine, in the same position as mine on your picture.

Then go to position D. Make no more corrections. If there was a correction at position B, indicate this on the observation sheet. Enter all the child's responses as in Problem 1. Never suggest to the child that his man is incorrectly placed.

POSITION INDICATED BY E	POSITION(S) INDICATED BY S			MANNER OF POSITIONING		
				IMMEDIATE	TENTATIVE	TRIAL AND ERROR
1 B	_____	_____	_____	_____	_____	_____

Correction at position B: Yes _____ No _____

2 D	_____	_____	_____	_____	_____	_____
3 G	_____	_____	_____	_____	_____	_____
4 A	_____	_____	_____	_____	_____	_____
5 L	_____	_____	_____	_____	_____	_____
6 E	_____	_____	_____	_____	_____	_____
7 K	_____	_____	_____	_____	_____	_____
8 I	_____	_____	_____	_____	_____	_____
9 J	_____	_____	_____	_____	_____	_____
10 H	_____	_____	_____	_____	_____	_____
11 C	_____	_____	_____	_____	_____	_____
12 F	_____	_____	_____	_____	_____	_____

SCORE A - G = ; H - L = .

NAME: ____________________ SCHOOL: _________________ DATE: _________

CONCEPTS OF LEFT AND RIGHT.

Material: Six various objects: wooden block, miniature bird, toy house, miniature car, miniature plate, pencil; one sheet of paper (21 X 25 cm) as a base; one rectangular piece of cardboard (28 X 36 cm) as a screen.

Procedure: General Directions: During the whole test, the child must be placed beside the examiner, except for section 2 where the examiner and the subject are standing and facing each other.

Section 1: Designation of the Subject's Body Parts.
Make sure that the child is paying attention and ask him the following questions successively, noting the child's response (gesture) each time.

QUESTION	RESPONSE	
	SHOWS RIGHT	SHOWS LEFT
(a) Show me your right hand	__________	__________
(b) Show me your left leg	__________	__________
(c) Show me your right ear	__________	__________
(d) Show me your left hand	__________	__________
(e) Show me your right leg	__________	__________
(f) Show me your left ear	__________	__________

Section 2: Designation of Parts of the Examiner.
The examiner stands up and asks the child to stand up and face him. First, make sure of the child's attention, then ask him successively each of the following questions, noting each of the child's responses (gestures).

QUESTION	RESPONSE	
	SHOWS RIGHT	SHOWS LEFT
(a) Show me my left hand		
(b) Show me my right ear		
(c) Show me my left leg		
(d) Show me my right hand		
(e) Show me my left ear		
(f) Show me my right leg		

Section 3: Relative Position of Three Objects.

Problem 3a. (Uncovered Objects)

Place the sheet of paper on the table, in front of the child; then arrange the block, the plate, and the pencil on this sheet (from left and right in relation to the examiner and to the subject, who are sitting side by side). Secure the child's attention and ask him successively each of the following questions, noting his responses verbatim each time.

QUESTION	RESPONSE	
	TO THE RIGHT	TO THE LEFT
(a) Is the pencil to the left or to the right of the plate?	R	
(b) Is the plate to the left or to the right of the block?	R	
(c) Is the block to the left or to the right of the pencil?		L
(d) Is the pencil to the left or to the right of the block?	R	
(e) Is the plate to the left or to the right of the pencil?		L
(f) Is the block to the left or to the right of the plate?		L

Problem 3b. (Hidden Objects)

Place the screen vertically in front of the child so that he can no longer see the objects on the sheet of paper. Then replace the three objects used in the preceding problem with the following three objects: the bird, the house, the car (from left to right in relation to the examiner and to the subject). Arrange these objects while taking care that the child does not see them. Then say:

Now, you have to pay very close attention. You see, I am putting this (the screen) here so you can't see what is on the paper right away. I took away everything that was there before and I put some other objects there. In a minute I'm going to remove the piece of cardboard so you can see; but afterward I'm going to put it back and I will ask you questions to see if you can remember how the objects are arranged on the paper. Now, you have to pay very close attention, you are going to look at the objects so you can remember afterward how they are arranged. Pay close attention because I'm only going to let you see them for a very short time.

Remove the screen and let the child look for about 15 seconds (count to 15 slowly). After this time, replace the screen in front of the objects and ask the child each of the following questions, noting his response each time.

QUESTION	RESPONSE	
	TO THE RIGHT	TO THE LEFT
(a) Is the bird to the left or to the right of the house?		L
(b) Is the house to the left or to the right of the car?		L
(c) Is the car to the left or to the right of the house?	R	
(d) Is the bird to the left or to the right of the car?		L
(e) Is the house to the left or to the right of the bird?	R	
(f) Is the car to the left or to the right of the bird?	R	

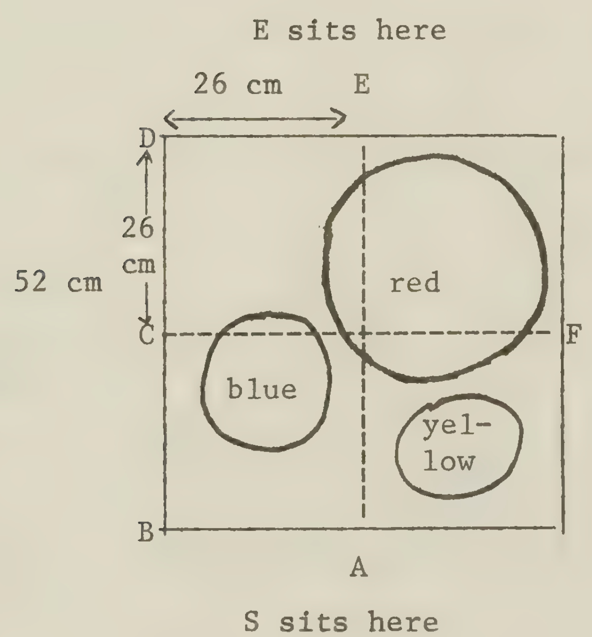
NAME: ________________ SCHOOL: ________________ DATE: ____________

COORDINATION OF PERSPECTIVES

Material: Three plastic models of "mountains": one red (diameter: 20 cm; height: 11.5 cm); one blue (diameter: 14 cm; height: 7.5 cm); one yellow (diameter: 9 cm; height: 5 cm); one piece of green cardboard (52 X 52) on which three circles showing the position of the "mountains" are marked (the square base is made of four smaller pieces of equal size (26 X 26 cm) bound together by masking tape, and the cross formed by these two lines serves as a reference point to estimate the degree of overlap of the "mountains", a set of nine cards (14 X 18 cm) illustrating the three "mountains" from various perspectives, in miniature (two of these, H & I are impossible given the actual position of the "mountains".); a small man of modeling clay (about 3 cm high).

Procedure: General Directions: Place the three "mountains" on the green cardboard at the three positions indicated by the circles:

FIGURE 1



Place the arrangement in front of the child so that the yellow "mountain" (small) is to his right, the blue "mountain" (medium) is to his left, and the red "mountain" (large) is behind the other two. Explain the material to the child, saying:

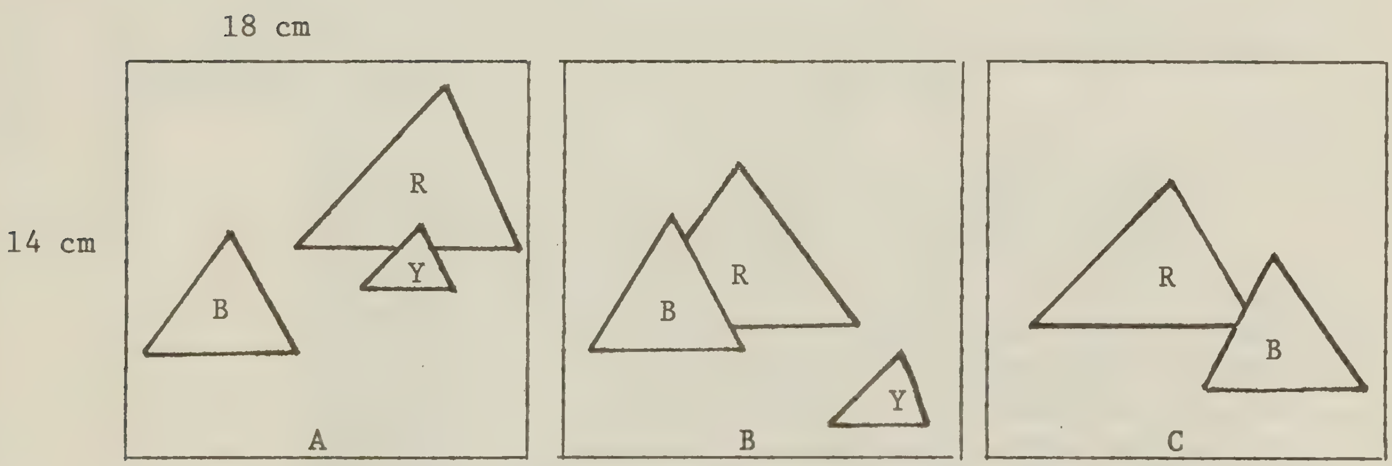
"Now we are going to play with some "mountains". You see, I have three "mountains": a red one, the biggest one; a blue one, a little smaller; and then a yellow one which is very small. I also have a little man (show the modeling-clay man). You can see how small he is. So the mountains are very big for him, because he is very small.

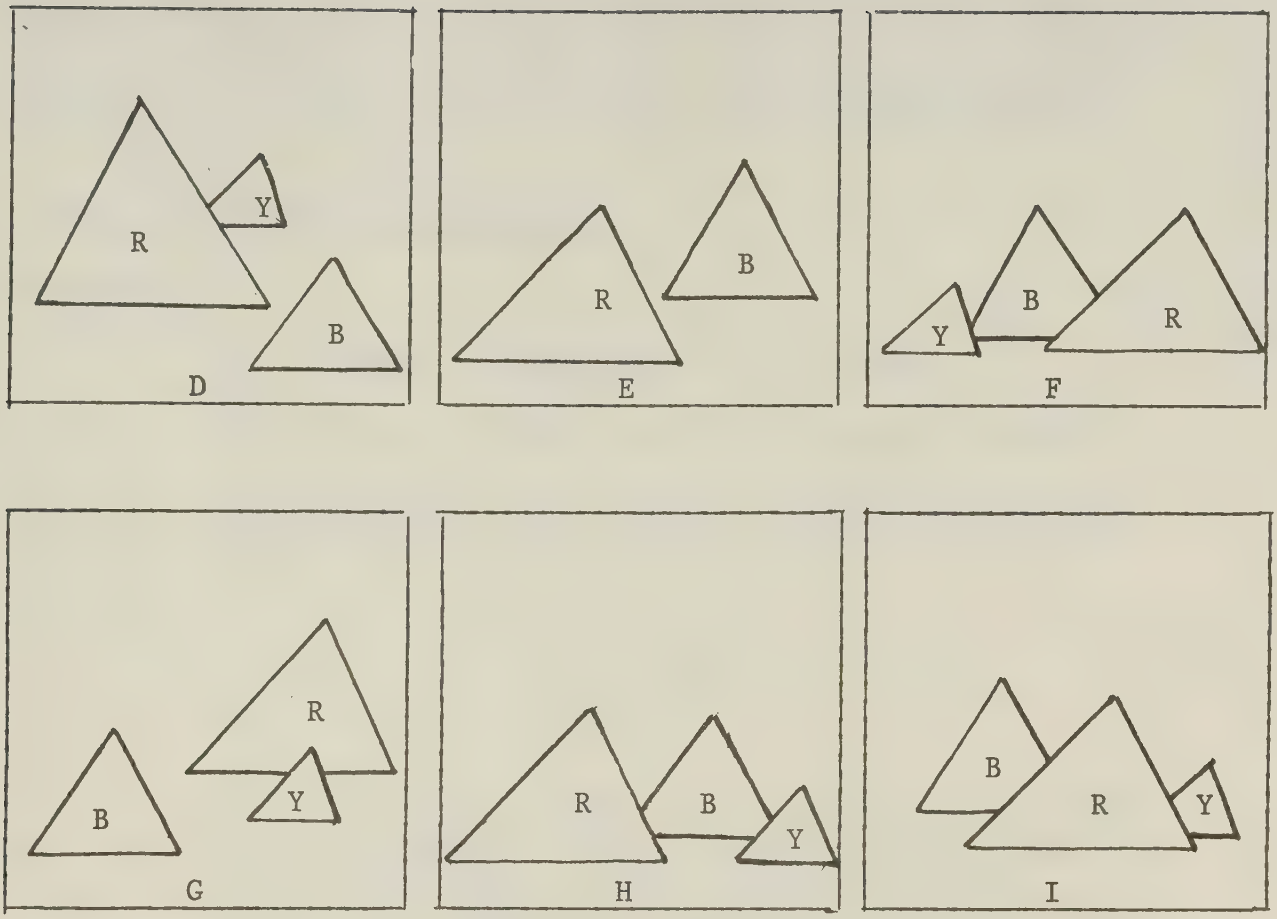
The man, right now, is going for a walk around the mountains, and he is going to take some pictures of the mountains. He has his camera with him and he wants to take pictures of the mountains. Now, you have to guess what will be in the pictures that the little man is going to take."

<u>Example</u>: Place the man at A (see Figure 1), just in front of the child, and say:

"Watch, I am putting the man here. Now, what does the little man see? What will the photograph look like when he takes it?"

FIGURE 2





Present cards A and D and say:

Try to find which of these pictures the little man sees when he is like this.

Let the child work. When he has made his choice (correct or not), explain the problem to him in the following way:

> "You see, the man is placed right in front of you. So he sees the same thing that you do: he sees the red "mountain" in the back, and the blue one to the left here, and then the yellow one to the right, here. So you see, he sees this picture (point to card A). On this picture, the red one is in the back, then the blue one is to the left, and the yellow one is to the right, in front of the red one. On the other picture (show Card D) the red one is in front of the yellow one, and the blue one is on the wrong side. To see it like this, he would have to go somewhere else. Do you understand?"

Repeat these explanations if necessary, but do not use other examples. In particular, never say to the child which position corresponds to card D, and, above all, never place the child at position D in order to show him that card D corresponds to a possible point of view.

First part (recognizing the card):

Problem 1:

Put the man at F (see Figure 1) and say:

"Now the man is there, and he is taking a picture."

Present cards G, A, D, F, H, in that order and in a horizontal line, with card G on the child's right:

E

H F D A G

S

Say: "Now you see that I have some pictures of the three "mountains". You are going to tell me which of these photographs the man is going to take when he is placed there (designate the man placed in F). Show me the picture that the man sees when he is there."

N. B. If the child wants to move so he can better see what the man sees, it is absolutely necessary to keep him from doing so. Note carefully which picture (S) the child chooses. If he proposes a single solution, question him first on the card he selected as the right one:

"Explain to me why you say that he can see that one."

Note his explanations carefully. Then ask him, successively pointing to each of the cards which he considered to be wrong:

"And that one, you are sure he doesn't see that one? Explain to me why he doesn't see that one."

Note responses verbatim and make sure he justifies his responses.

If the child proposes several solutions ask him:

"Which one is the best one of all? Explain to me why that one is the best."

Note his explanations carefully. Then take each of the cards which he chose at first, but which he rejected when he chose the best one, and ask for each one:

> "And that one, you just chose it a little while ago; why do you think that it's not right, why do you think that the man doesn't see that one?"

Finally, take each of the cards which the child has just considered as the wrong ones and ask for each one:

> Explain to me why he doesn't see that one.

Problem 1:

Position F: Cards: G, A, D, F, H

Card(s) selected as correct: 1) __ 2) __ 3) __ 4) __ 5) __
If S proposes a single solution, indicate his justification:

a) for the single solution: Card: ______

b) for the others not chosen: Card: ______
Card: ______
Card: ______
Card: ______

If S proposes several solutions:

a) for the one he considers best: Card: ______

b) for the cards chosen but rejected: Card: ______
Card: ______
Card: ______
Card: ______

c) for the card(s) he considers incorrect: Card: ______
Card: ______
Card: ______

Problem 2:

Position C; Cards: E, C, F, A, B.

Card(s) selected as correct: 1) __ 2) __ 3) __ 4) __ 5) __
If S proposes a single solution, indicate his justification:

a) for the single solution: Card: _____

b) for the others not chosen: Card: _____

Card: _____

Card: _____

Card: _____

If S proposes several solutions:

a) for the one he considers best: Card: _____

b) for the cards chosen but rejected: Card: _____

Card: _____

Card: _____

Card: _____

c) for the card(s) he considers incorrect: Card: _____

Card: _____

Card: _____

Problem 3:

Position E

Ask the subject to place himself at E (beside the examiner) saying:

"Now you are going to sit beside me to see the "mountains" the way I see them. What do you see when you are here? Make yourself very small like the little man (encourage the child to bend down) and look at the "mountains" very carefully so you can tell me what you see. Which "mountains" do you see?"

Response: ____

If he says three (he sees only two) do not insist further.

<u>Position B</u>; Cards: B, I, E, D, A.

Card(s) selected as correct: 1) __ 2) __ 3) __ 4) __ 5) __
If S proposes a single solution, indicate his justification:

a) for the single solution: Card: _______

b) for the others not chosen: Card: _______

Card: _______

Card: _______

Card: _______

If S proposes several solutions:

a) for the one he considers best: Card: _______

b) for the cards chosen but rejected: Card: _______

Card: _______

Card: _______

Card: _______

c) for the card(s) he considers incorrect: Card: _______

Card: _______

Card: _______

APPENDIX B

CRITERIA OF STAGES

Criteria of Stages

Conservation of Number

Stage I: Global comparisons.

The subject's judgment about number is vague. He does not realize that number remains invariant despite the rearrangement of a set of objects.

Stage II: Intuitive stage.

The subject begins to realize that perceptual transformation does not change the attributes of quantity and number with respect to a given set of objects. He conserves small numbers; that is, he can correctly answer the questions related to the rows of nine yellow and blue blocks.

Stage III: Concrete operations.

The subject knows that perceptual transformation does not change quantity and number and that the altered configuration can be returned to the original state. The subject correctly answers all questions concerning the rows of nine and twenty yellow and blue blocks. Equivalence is argued of the bases that no blocks have been added or subtracted.

Additive Composition of Classes

Stage I: Absence of Additive Composition

The subject does not understand that the B class (wooden beads) will always contain more elements than the A (red beads) and A^1 (white beads) classes. He does not think simultaneously of the whole B and the parts A and A^1. There is no understanding that $B = A + A^1$ and that $A = B - A^1$. Even when the subject makes and compares the necklaces this is not understood.

Stage II: Intuitive stage.

The subject gradually realizes that the B class (wooden beads) contains more elements than either the A (red beads) or A^1 (white beads) classes. This intuitive discovery is made only when the subject is compelled to make the necklaces and to visualize the sets. He finds that the B (wooden beads) class is larger than the A (red beads) class but he does not assume this fact because of the inclusions resulting from additive composition.

Stage III: Concrete operations.

The subject immediately grasps that class B (wooden beads) is larger than class A (red beads) and can explain his answer in terms of additive composition.

Multiplicative Classification

Stage I: Graphic collections.

The subject does not sort the material into the four groups of blue circles, blue squares, red circles and red squares. Rather he uses the material to form linear alignments, collective objects or complex objects. Linear alignments involve the construction of a number of independent arrangements with only part of the material. A collective object is a two or three dimensional collection of similar elements which form a unified figure. A complex object involves the arrangement of heterogeneous elements to form a two dimensional shape which is often geometric in form.

Stage II: Non-graphic collections.

A gradual transition from simple classification (the two criteria of color and shape are considered separately) toward multiplicative classification (the simultaneous consideration of the criteria of color and shape) may be observed. At this stage the subject will usually sort the geometric shapes on the bases of one criterion either color or shape but he may be led to regroup the material on the basis of a second criterion.

Stage III: Concrete operations.

The subject sorts the material on the basis of both criteria, color and shape. He can immediately cross-classify and recognize that two classes may overlap with respect to membership. All questions regarding the classification are answered correctly.

Seriation

Stage 0: Total incomprehension.

The subject has no understanding of the task and cannot form a correct series from the pictures of either the flowers or vases.

Stage I: Construction of a serial correspondence.

The subject can correctly order the two series of pictures of flowers and vases which have been drawn to different scales.

Stage II: Progressive seriation and correspondence.

The subject can indicate the correct correspondence when the two series are left parallel but not when the elements of one are pushed closer together so that the corresponding elements are no longer opposite to each other. At this stage a transition to ordinal correspondence occurs but the correspondence is intuitive and perceptual.

Stage III: Operational seriation.

The subject can indicate the correct correspondence when one of the series is disarranged. At this stage coordination between cardinal and ordinal numbers is achieved.

The Duality Principle

Stage I: Spontaneous Classification.

The subject correctly sorts the classes ducks, birds not ducks, and animals not birds, but answers all the questions incorrectly.

Stage II

The subject correctly sorts the classes ducks, birds not ducks, and animals not birds and answers the section four questions on straight negation of classes correctly. Answers to all the other questions are incorrect.

Stage III: Concrete operations.

The subject succeeds with the questions on inclusion and subtraction of classes, but fails with the questions on the Duality Principle.

Stage IV: Formal operations.

The subject answers all the questions correctly including the questions on the Duality Principle. The relationship between the ordering of classes and the ordering of their complements as expressed by: $(A) < (B) \longrightarrow (\text{not}-A) > (\text{not}-B)$ is understood.

Concepts of Left and Right

Stage 0: Total incomprehension.

Stage I: Relation of internal opposition only.

Substage IA: The subject's concepts of left and right are very weak and unstable. He cannot properly designate left and right on his own body.

Substage IB: The subject correctly designates left and right on his own body but fails the other problems.

Stage II: Relation of external opposition, but subjective only.

The subject correctly designates the left and right parts of the examiner's body when they stand facing each other. Thus he is able to reverse the left and right relations which he has established on his own body and adapt them to the specific viewpoint of the person opposite.

Stage III: Concrete operations and objective opposition relation.

Substage IIIA: The subject correctly answers all the problems in which he is asked to describe the relative positions of three visible objects placed in front of him. The subject grasps the true meaning of the expressions "to the left of" and "to the right of". He is able to coordinate the ocncepts of left and right from various points of view.

Substage IIIB: The subject correctly answers all the problems in which he is asked to describe the relative positions of three hiddden objects.

The Localization of Topographical Positions

Stage 0: Total incomprehension.

Stage I: Topological solutions, search for symmetry and gesture imitation.

The subject understands the nature of the task and can properly position the houses on the landscape. He experiences isolated successes with some of the problems but these correct responses are below the minimum numbers required at each of the four levels of difficulty of the sequence of stages.

Stage II: Progressive but still egocentric use of projective relations (left-right and before-behind).

Substage IIA: The subject successfully completes at least five out of seven problems at the first level of difficulty. These are the problems (A - G) that deal with left-right relationships. He is not able to solve the number of problems required for success at the other three levels of difficulty.

Substage IIB: The subject who has been successful at Substage IIA correctly solves at least four of the five problems at the second level of difficulty. These problems (H to L) deal with before-behind relationships.

Stage III: Operational coordination of projective relations.

Substage IIIA: At this substage the subject has been successful with the requirements of Substages IIA and IIB. He correctly solves at least five of the seven problems at the third level of difficulty. These problems (A - G) deal with left-right relationships when one of the landscapes has been rotated.

Substage IIIB: The subject solves at least four of the five problems at the fourth level of difficulty. These problems deal with the relationships of before-behind when one of the landscapes has been rotated. At this final stage the subject is capable of the necessary coordinations and reversals required for success at all four levels of difficulty.

Coordination of Perspectives

Stage O: Total incomprehension.

The subject is not able to grasp the nature of the task.

Stage I: Complete egocentrism.

Substage IA: Overt egocentrism.

The subject tends to select egocentric views for each of the positions F, C and B. However, there are definite signs of incomprehension typical of Stage O.

Substage IIA: Pseudo egocentrism.

The subject consistently selects the egocentric pictures and

explains them from his own viewpoint. Some of the subject's explanations may suggest a mental anticipation of other perspectives but there is no real decentration.

Stage II: Partial decentration.

Substage IIA: The subject is able to achieve one out of three decentred responses. However, many of the explanations he makes include the egocentrism of the previous stage.

Substage IIB: The subject is completely successful with two of the three problems. He is capable of making two totally decentred responses.

Stage III: Operational coordination.

The subject is successful with all three problems. He is able to recognize in each case the picture which represents the "man's" point of view and his explanations indicate that he can coordinate the projective relations of left-right and before-behind involved in the test.

APPENDIX C

STAGE PERFORMANCE ON PIAGETIAN TASKS FOR ALL SUBJECTS

TABLE 10

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CONTROL CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	101	133/117/143	87	83	III (7)	III (7)	III (7)	III (7)	I (3)	IIIB (7)	IIIA (6)	IIA (4)	
2	102	120/ 92/ 97	79	50	III (7)	II (5)	II (5)	III (7)	II (5)	II (5)	IIIB (7)	IIA (4)	
3	104	105/121/109	59	92	III (7)	III (7)	III (7)	III (7)	I (3)	II (5)	IIIA (6)	III (7)	
4	105	105/110/ 99	53	60	III (7)	III (7)	III (7)	I (3)	II (5)	IB (3)	IIIA (6)	IIB (5)	
5	105	122/114/114	99	99	III (7)	III (7)	III (7)	II (5)	II (5)	IB (3)*	IIIA (6)	IIB (5)	
6	106	132/113/115	96	99	III (7)	III (7)	III (7)	III (7)	II (5)	IIIB (7)	IIIB (7)	III (7)	
7	106	111/111/ 97	85	92	III (7)	III (7)	III (7)	III (7)	I (3)	IB (3)	IIIA (6)	IIA (4)	
8	108	114/115/ 97	87	83	III (7)	III (7)	II (5)	I (3)	II (5)	II (5)	IIIA (6)	IIA (4)	
9	109	111/106/100	56	96	III (7)	I (3)	III (7)	II (5)	II (5)*	IIIB (7)	IIIA (6)	IIB (5)	
10	111	99/105/ 93	56	72	III (7)	III (7)	III (7)	III (7)	I (3)	IIIB (7)	IIIA (6)	IIA (4)	

! Canadian Cognitive Abilities Test

X Stanford Achievement Test

O Edmonton Public School Board Tests for Mathematics

* Skipped Stage

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 11

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS WITH READING PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	103	93/ 92/ 93	3	60	III (7)	II (5)	II (5)	II (5)	I (3)	IA (2)	IIB (5)	IIA (4)	
2	106	98/109/100	1 year + below Gr. level	72	III (7)	III (7)	I (3)	II (5)	II (5)	IIIB (7)	IIA (4)*	IIA (4)	RT
3	108	87/ 87/ 93	9	36	III (7)	I (3)	I (3)	II (5)	I (3)	IA (2)	IIIA (6)	IB (3)	
4	108	106/103/ 86	1 year + below Gr. level	At Grade level	III (7)	III (7)	III (7)	I (3)	II (5)*	II (5)	IIA (4)	IIB (5)	RT
5	108	77/ 84/ 95	7	32	III (7)	III (7)	II (5)	I (3)	I (3)	IB (3)	IIIA (6)	IB (3)	
6	109	92/ 98/ 97	3	40	III (7)	III (7)	III (7)	III (7)	II (5)*	IB (3)*	IIIA (6)	IA (2)	
7	109	104/ 99/ 88	3	55	III (7)	III (7)	II (5)	II (5)	II (5)	IA (2)	IIIA (6)	IIA (4)	
8	110	89/ 87/ 98	1 year + below Gr. level	At Grade level	III (7)	III (7)	III (7)	II (5)	II (5)	IB (3)	IIB (5)	IIB (5)	RT
9	111	87/ 98/ 83	6	45	III (7)	III (7)	III (7)	II (5)	I (3)	II (5)	IIA (4)*	IB (3)	
10	112	80/ 94/101	11	60	III (7)	III (7)	I (3)	II (5)	II (5)	IA (2)*	IIB (5)	IB (3)	

! Canadian Cognitive Abilities Test

X Stanford Achievement Test

O Edmonton Public School Board Test for Mathematics

* Skipped Stage

RT = Recommended by Teacher

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 12

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS WITH ARITHMETIC PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	88	not available	98	Below Gr. level	III (7)	I (3)	II (5)	I (3)	I (3)	IB (3)	IIB (5)	IB (3)	
2	98	93/ 90/ 89	32	4	III (7)	I (3)	III (7)	I (3)	I (3)	II (5)	IIIA (6)	IIA (4)	
3	102	94/ 92/ 85	43	3	III (7)	II (5)	I (3)	I (3)	I (3)	IB (3)	IIIA (6)	0 (1)	
4	102	107/103/101	At Grade level 29	7	III (7)	III (7)	II (5)	I (3)	I (3)	II (5)	IIIA (6)	IB (3)	
5	103	111/114/107	97	10	III (7)	III (7)	III (7)	II (5)	I (3)	IB (3)	IIIA (6)	IB (3)	
6	105	111/ 96/111	45	11	III (7)	I (3)	III (7)	II (5)	I (3)	II (5)	IIIA (6)	IB (3)	
7	106	100/ 83/ 93	At Grade level 26	2	III (7)	III (7)	II (5)	II (5)	I (3)	II (5)*	IIA (4)*	IA (2)	
8	106	123/ 83/ 93	39	6	III (7)	I (3)	III (7)	I (3)	I (3)	IB (3)	IIA (4)*	IIA (4)	

! Canadian Cognitive Abilities Test

X Stanford Achievement Test

O Edmonton Public School Board Tests for Mathematics

* Skipped Stage

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 13

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS WITH BEHAVIOR PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	81	Binet 88	Gr. 1	Gr. 1	III (7)	III (7)	II (5)	I (3)	I (3)	IB (3)	IIB (5)	IA (2)	
2	89	-/111/ -	Gr. 2	Gr. 2	II (5)	I (3)	I (3)	0 (1)	I (3)	IA (2)	IIB (5)	0 (1)	
3	96	105/101/102	Gr. 3	Gr. 2	III (7)	III (7)	III (7)	III (7)	II (5)	II (5)	IIIA (6)	IIA (4)	
4	102	119/107/115	Gr. 3	Gr. 3	III (7)	III (7)	II (3)	II (5)	II (5)	II (5)	IIIA (6)	IIB (5)	
5	109	98/108/102	Gr. 3	Gr. 3	III (7)	III (7)	III (7)	II (5)	II (5)	IA (2)	IIA (4)*	IA (2)	
6	109	103/120/115	Gr. 3	Gr. 3	III (7)	I (3)	I (3)	II (5)	I (3)	II (5)	IIIA (6)	III (7)	
7	111	118/115/119	Gr. 3	Gr. 3	III (7)	III (7)	III (7)	II (5)	II (5)	IIIB (7)	IIIB (7)	III (7)	
8	111	91/101/ 95	Gr. 3	Gr. 2	III (7)	II (5)	II (5)	I (3)	I (3)	IA (2)	IIB (5)	IB (3)	

! Wechsler Intelligence Scale for Children

X Teacher Assessments

O Teacher Assessments

* Skipped Stage

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 14

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS WITH READING AND ARITHMETIC PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	99	WPPSI 89/ 99/ 93	1 year + below Grade level		III (7)	III (7)	III (7)	II (5)	I (3)	II (5)	IIA (4)*	IB (3)	RT
2	99	WISC 103/100/101	1 year + below Grade level		III (7)	I (3)	III (7)	II (5)	I (3)	II (5)	IIA (4)	IA (2)	RT
3	102	100/ 80/ 92	7	3	III (7)	II (5)	III (7)	II (5)	II (5)	IB (3)	IIA (4)*	III (7)	
4	103	103/102/106	1 year + below Grade level		III (7)	II (5)	II (5)	III (7)	II (5)	IB (3)	IIIA (6)	IIB (5)	RT
5	106	92/ 87/100	7	10	III (7)	I (3)	I (3)	II (5)	I (3)	IA (2)	IIIA (6)	IA (2)	
6	106	82/ 72/ 89	1 year + below Grade level		III (7)	I (3)	II (5)	II (5)	I (3)	IB (3)	IIA (4)	IB (3)	RT
7	107	88/ 90/108	1	3	III (7)	III (7)	III (7)	II (5)	I (3)	IB (3)	IIA (4)*	IIA (4)	
8	107	WISC 113/111/113	1 year + below Grade level		III (7)	II (5)	II (5)	II (5)	II (5)	IB (3)	IIIA (6)	IB (3)	RT
9	112	71/ 63/ 88	11	2	III (7)	III (7)	II (5)	II (5)	II (5)	IB (3)	IIB (5)	IIA (4)	

! Canadian Cognitive Abilities Test

X Stanford Achievement Test

O Edmonton Public School Board Tests for Mathematics

* Skipped Stage

RT = Recommended by Teacher

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 15

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN YOUNGER THAN NINE YEARS SIX MONTHS WITH READING, ARITHMETIC AND BEHAVIOR PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	102	Binet 98			III (7)	III (7)	II (5)	II (5)	II (5)	IB (3)	IIIA (6)	IA (2)	
2	104	FS WISC 90			III (7)	III (7)	III (7)	II (5)	I (3)	IB (3)	IIA (4)	IIB (5)	
3	107	108/120/110			III (7)	III (7)	II (5)	II (5)	III (7)	II (5)	IIIA (6)	IIA (4)	
4	110	80/ 96/ 87			III (7)	I (3)	I (3)	II (5)	I (3)	IB (3)	IIIB (7)	IB (3)	
5	110	92/ 85/ 85			III (7)	III (7)	III (7)	I (3)	I (3)	IA (2)*	IIA (4)	O (1)	
6	111	108/100/104			III (7)	I (3)	II (5)	II (5)	I (3)	II (5)	IIA (4)	IA (2)	
7	111	97/ 97/ 97			III (7)	III (7)	III (7)	III (7)	II (5)	II (5)	IIB (5)	IA (2)	
8	112	85/100/ 91			III (7)	I (3)	II (5)	II (5)	I (3)	II (5)	IIB (5)	IB (3)	
9	114	92/ 93/ 92			III (7)	II (5)	III (7)	II (5)	I (3)	IB (3)	IIIA (6)	IA (2)	
10	114	84/101/ 91			III (7)	III (7)	II (5)	II (5)	I (3)	IA (2)	IIIA (6)	IA (2)	

! Wechsler Intelligence Scale for Children

X O All subjects at least one year below expected grade level in reading and arithmetic (Teacher assessments)

* Skipped Stage

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 16

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CONTROL CHILDREN OLDER THAN NINE YEARS SIX MONTHS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	135	120/120	82	83	III (7)	III (7)	III (7)	III (7)	IV (8)	IIIB (7)	IIIB (7)	III (7)	
2	136	121/116	46	94	III (7)	III (7)	III (7)	III (7)	IV (8)	IIIA (6)	IIIB (7)	III (7)	
3	137	122/125	75	74	III (7)	III (7)	III (7)	III (7)	IV (8)	IIIB (7)	IIIB (7)	III (7)	
4	139	125/110	82	43	III (7)	III (7)	III (7)	III (7)	IV (8)	IIIB (7)	IIIB (7)	III (7)	
5	143	115/143	82	99	III (7)	III (7)	III (7)	III (7)	IV (8)	IIIB (7)	IIIB (7)	III (7)	
6	144	119/125	93	91	III (7)	III (7)	III (7)	III (7)	IV (8)	IIIB (7)	IIIB (7)	III (7)	
7	145	103/119	58	50	III (7)	III (7)	III (7)	III (7)	IV (8)	IIIA (6)	IIIB (7)	III (7)	
8	146	99/106	58	71	III (7)	III (7)	III (7)	III (7)	IV (8)	IIIB (7)	IIIA (6)	III (7)	
9	146	121/131	88	82	III (7)	III (7)	III (7)	III (7)	IV (8)	IIIB (7)	IIIB (7)	III (7)	
10	149	89/89	43	31	III (7)	III (7)	III (7)	III (7)	III (7)	II (5)	IIIB (7)	IIB (5)	

! Lorge Thorndike Intelligence Test

X Stanford Achievement Test

O Edmonton Public School Board Tests for Mathematics

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 17

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN OLDER THAN NINE YEARS SIX MONTHS WITH READING PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	116	WISC 111/121/119	end Gr. 1	end Gr. 2	III (7)	III (7)	III (7)	II (5)	II (5)	II (5)	IIIB (7)	III (7)	
2	122	WISC 79/100/ 88	9	92	III (7)	III (7)	II (5)	II (5)	I (3)	II (5)	IIA (4)*	IIA (4)	
3	130	105/109	1 year + below Gr. level	92	III (7)	III (7)	III (7)	III (7)	III (7)	IIIB (7)	IIIB (7)	III (7)	RT
4	131	WISC 118/111/115	1 year + below Gr. level	Grade level	III (7)	III (7)	II (5)	II (5)	I (3)	II (5)	IIIB (7)	III (7)	RT
5	136	108/127	6	40	III (7)	III (7)	III (7)	II (5)	II (5)	IIIB (7)	IIIB (7)	IIB (5)	
6	140	93/110	6	31	III (7)	II (5)	III (7)	II (5)	III (7)	II (5)*	IIIB (7)	IIB (5)	
7	143	-/108	5	46	III (7)	III (7)	III (7)	III (7)	II (5)	II (5)	IIIA (6)	IIB (5)	
8	145	WISC 100/153/127	3	56	III (7)	III (7)	III (7)	II (5)	II (5)	IIIA (6)	IIIA (6)	III (7)	
9	146	100/128	10	82	III (7)	III (7)	III (7)	III (7)	II (5)	IIIB (7)	IIIB (7)	III (7)	
10	150	73/ 95	10	43	III (7)	III (7)	III (7)	III (7)	II (5)	IIIB (7)	IIIB (7)	III (7)	

! Lorge Thorndike Intelligence Test

X Stanford Achievement Test

O Edmonton Public School Board Tests for Mathematics

* Skipped Stage

RT = Recommended by Teacher

Roman Numeral = = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 18

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN OLDER THAN NINE YEARS SIX MONTHS WITH ARITHMETIC PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	125	WISC 98/100/100	Grade level	1 year + below Gr. level	III (7)	II (5)	III (7)	II (5)	I (3)	II (5)	IIA (4)	IB (3)	RT
2	141	95/107	45	13	III (7)	III (7)	II (5)	II (5)	II (5)	II (5)	IIIA (6)	IIB (5)	
3	143	87/109	35	4	III (7)	III (7)	III (7)	III (7)	I (3)	IIIB (7)	IIIB (7)	III (7)	
4	144	86/101	35	8	III (7)	III (7)	III (7)	I (3)	II (5)	IIIA (6)	IIIB (7)	IIB (5)	
5	145	80/ 92	43	8	III (7)	III (7)	III (7)	II (5)	II (5)	II (5)	IIIA (6)	IIA (4)	
6	146	80/ 87	39	2	III (7)	III (7)	II (5)	II (5)	II (5)	II (5)	IIIA (6)	IIA (4)	
7	146	101/102	55	8	III (7)	III (7)	III (7)	III (7)	II (5)*	IB (3)	IIIA (6)	IIB (5)	
8	149	WISC 89/ 87/ 87	35	1	III (7)	III (7)	II (5)	II (5)	II (5)	II (5)	IIIB (7)	IIA (4)	
9	161	WISC 94/101/96	Grade level	1 year + below Gr. level	III (7)	III (7)	II (5)	II (5)	II (5)	IIIB (7)	IIIA (6)	IIA (4)	RT
10	164	WISC 94/101/ 96	Grade 9	Grade 5.5	III (7)	III (7)	II (5)	II (5)	I (3)	IIIB (7)	IIIA (6)	III (7)	
11	168	WISC 102/ 85/ 92	Grade 8	Grade 2.5	III (7)	III (7)	II (5)	I (3)	I (3)	IB (3)*	IIA (4)	IIB (5)	

! Lorge Thorndike Intelligence Test

X Stanford Achievement Test

O Edmonton Public School Board Tests for Mathematics

* Skipped Stage

RT = Recommended by Teacher

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 19

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN OLDER THAN NINE YEARS SIX MONTHS WITH BEHAVIOR PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOGRAPHICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	120	81/108/ 93	end Gr. 3	end Gr. 3	III (7)	III (7)	II (5)	III (7)	II (5)	IIIB (7)	IIIB (7)	IB (3)	
2	136	73/105/ 87	Gr. 5	Gr. 5	III (7)	I (3)	II (5)	II (5)	II (5)	II (5)	IIIA (6)	III (7)	
3	136	90/ 78/ 83	Gr. 3	Gr. 3	I (3)	III (7)	II (5)	II (5)	I (3)	II (5)	IIB (5)	III (7)	
4	147	85/101/ -	Gr. 7	Gr. 6	III (7)	III (7)	III (7)	II (5)	II (5)	II (5)	IIA (4)*	IB (3)	
5	152	98/104/101	Gr. 6.5	Gr. 6	III (7)	III (7)	III (7)	II (5)	II (5)	IIIB (7)	IIIB (7)	IB (3)	
6	155	118/118/120	Gr. 7	Gr. 7	III (7)	III (7)	III (7)	II (5)	II (5)*	IIIB (7)	IIIB (7)	III (7)	
7	158	95/118/107	Gr. 5-6	Gr. 5-6	III (7)	III (7)	III (7)	III (7)	II (5)	II (5)	IIIB (7)	IIB (5)	
8	161	102/117/109	Gr. 8	Gr. 8	III (7)	III (7)	III (7)	II (5)	II (5)	IB (3)*	IIIB (7)	III (7)	
9	165	107/106/107	Gr. 8	Gr. 6	III (7)	III (7)	III (7)	II (5)	II (5)	IIIB (7)	IIIB (7)	III (7)	

! Wechsler Intelligence Scale for Children

X Teacher Assessments

O Teacher Assessments

* Skipped Stage

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 20

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN OLDER THAN NINE YEARS SIX MONTHS WITH READING AND ARITHMETIC PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOLOGICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	117	WISC 89/ 90/ 88	1 year + below Grade level		III (7)	III (7)	III (7)	II (5)	II (5)	IB (3)	IIA (4)*	IB (3)	RT
2	124	92/111/104	1 year + below Grade level		III (7)	III (7)	III (7)	II (5)	I (3)	II (5)	IIIA (6)	IB (3)	RT
3	129	WISC av. ability	6	1	III (7)	I (3)	III (7)	II (5)	I (3)	IB (3)	IIA (4)*	IB (3)	
4	139	83/105	10	1	III (7)	III (7)	III (7)	III (7)	II (5)	IIIB (7)	IIIB (7)	IIA (4)	
5	141	WISC 94/111/102	1	6	III (7)	III (7)	II (5)	II (5)	II (5)	IIIB (7)	IIIA (6)	III (7)	
6	141	86/ 96	8	4	III (7)	III (7)	III (7)	II (5)	II (5)	II (5)*	IIIB (7)	III (7)	
7	144	77/ 98	6	8	III (7)	III (7)	III (7)	III (7)	II (5)	II (5)	IIIB (7)	IIB (5)	
8	144	WISC 90/ 96/ 90	1 year + below Grade level		III (7)	III (7)	III (7)	II (5)	II (5)	II (5)	IIIB (7)	IA (2)	RT
9	144	83/ 86	6	1	III (7)	III (7)	II (5)	II (5)	I (3)	II (5)	IIIA (6)	IA (2)	
10	144	WISC 91/ 90/ 99	2	5	III (7)	II (5)	III (7)	II (5)	II (5)	II (5)	IIIB (7)	IIB (5)	
11	148	WISC 85/ 99/ 91	5	6	III (7)	I (3)	III (7)	III (7)	II (5)	II (5)	IIIA (6)	IB (3)	
12	152	83/ 86	1 year + below Grade level		III (7)	II (5)	III (7)	II (5)	II (5)	IB (3)	IIA (4)*	IIA (4)	RT

! Lorge Thorndike Intelligence Test

X Stanford Achievement Test

O Edmonton Public School Board Tests for Mathematics

* Skipped Stage

RT = Recommended by Teacher

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

TABLE 21

STAGE PERFORMANCE ON PIAGETIAN TASKS BY CHILDREN OLDER THAN NINE YEARS SIX MONTHS WITH READING, ARITHMETIC AND BEHAVIOR PROBLEMS

SUBJECT	AGE IN MONTHS	IQ SCORE !	PERCENTILE READING X	PERCENTILE ARITHMETIC O	CONSERVATION OF NUMBER	ADDITIVE COMPOSITION	MULTIPLICATIVE CLASSIFICATION	SERIATION	DUALITY PRINCIPLE	CONCEPTS OF LEFT AND RIGHT	TOPOLOGICAL POSITIONS	COORDINATION OF PERSPECTIVES	COMMENTS
1	120	104/104/104			III (7)	III (7)	III (7)	III (7)	II (5)	IIIB (7)	IIIB (7)	IA (2)	
2	125	82/ 86/ 83			III (7)	III (7)	II (5)	III (7)	I (3)	IA (2)	IIIB (7)	IIB (5)	
3	125	92/ 97/ 94			III (7)	III (7)	II (5)	II (5)	II (5)	II (5)	IIB (5)	IA (2)	
4	126	97/106/100			III (7)	I (3)	III (7)	III (7)	I (3)	II (5)	IIIA (6)	III (7)	
5	146	85/ 84/ 85			III (7)	I (3)	III (7)	II (5)	I (3)	II (5)	IIIA (6)	IIA (4)	
6	147	PPVT 97			III (7)	III (7)	II (5)	III (7)	II (5)	II (5)	IIIA (6)	IIA (4)	
7	155	121/117/121			III (7)	III (7)	III (7)	III (7)	III (7)	IB (3)*	IIIB (7)	IIB (5)	
8	161	87/121/104			III (7)	III (7)	II (5)	III (7)	II (5)	II (5)	IIIB (7)	III (7)	
9	163	not available			III (7)	III (7)	III (7)	II (5)	II (5)	IIIB (7)	IIIA (6)	IIB (5)	
10	168	90/ 94/ 91			III (7)	III (7)	II (5)	I (3)	II (5)	IIIB (7)	IIIB (7)	IIA (4)	

! Wechsler Intelligence Scale for Children

X O All subjects at least one year below expected grade level in reading and arithmetic (Teacher assessments).

* Skipped stage

Roman Numeral = Piagetian Stage
Arabic Numeral = Numerical Score

B30171